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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
29 West Thirty-ninth Street, New York

JAMES HARTNESS
PRESIDENT 1914
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

THE ANNUAL MEETING

THE thirty-fourth Annual Meeting, held December 2 to 5, was one of the largest in the history of the Society, with a total registration of 1271, of which 778 were members. Following the plan of the last two years, the professional sessions were to a considerable extent in charge of sub-committees appointed by the Committee on Meetings, with the result that there were several symposiums on widely diversified subjects which gave a very broad scope to the meeting. The chief social event was the German Dinner on Thursday evening, planned to give those who were not of the party visiting Germany last summer an idea of the hospitality and unusual privileges shown the visitors, as well as to make an enjoyable reunion for those who spent the time together during the trip. Of very unusual interest, also, was the lecture by John W. Lieb, Jr., on the life and accomplishments of Leonardo da Vinci—one of the most remarkable lectures ever listened to by those in attendance at an annual meeting.

Another interesting social feature of the meeting was the tea and musicale given in the Society rooms on Wednesday afternoon under the auspices of the Ladies Reception Committee, Mrs. Edward Van Winkle, Chairman. This attracted a large attendance of members and guests.

An innovation was made this year in the holding on Friday evening of reunions of the engineering alumni of various colleges, which proved so successful that it will doubtless be made a permanent feature.

OPENING SESSION, TUESDAY EVENING

As usual, the meeting began on Tuesday evening in the auditorium of the Engineering Societies Building, with the President's address, delivered this year by Dr. W. F. M. Goss, on Education as a Feature in the Development of Professional Ideals, which is published in full in this number of The Journal.

Following the address Dr. Goss read the report of the tellers of election of officers, when the following results of the ballots cast were given: President, James Hartness; Vice-Presidents, Henry L. Gantt, E. E. Keller, H. G. Reist; Managers, A. M. Greene, Jr., John Hunter, Elliott H. Whitlock; Treasurer, Wm. H. Wiley.

The President-Elect, James Hartness, was next escorted to the platform, where he was received by the retiring President, who in introducing him referred to his broad experience in the field of industrial activity, his wide acquaintance among engineers, and his fine qualities as a man. Mr. Hartness in reply briefly expressed his realization of the responsibilities and high honor attached to the office of President of the Society, and his desire to give his best energies in furthering its interests.

WEDNESDAY MORNING SESSION

At the annual business meeting on Wednesday morning the reports of the Council and the Standing Committees were first presented. The former have already been published in The Journal, and the report of the Council will appear in Volume 35 of Transactions.

As a part of the required procedure, the proposed amendments to the Constitution, C-9 and C-11, were read. These specify more strict requirements for the grades of member and associate-member, raising the age requirement for the former to thirty-two years, and of the latter to twenty-seven years. A student rarely graduates from a technical school until the age of twenty-two, and under the new limits he will have at least ten years practice in his profession before qualifying for the grade of member, and five years for associate-member.

The next business in order was the report on Standard Threads for Hose Couplings offered at the request of the Sub-Committee on Fire Protection. This came as a result of the paper on this subject at the Spring Meeting by F. M. Griswold, who through consistent work for many years has secured the adoption of a standard by various organizations. The report advocates as a standard for 2½-in. hose connections a diameter of $3\frac{1}{16}$ in. over the thread with 7½ threads to the inch, this being an intermediary of designs in most general use, and thus allowing the greatest possible interchangeability of hose connections. Standards are recommended for other sizes also, and sample couplings to show the various standards were given to the Society as a present from the Committee. This report was accepted.

Following this, the Committee on the Standardization of Pipe Thread Gages presented a report, which was accepted.

Then followed a long discussion of a report by the Committee on the Standardization of Flanges. An abstract of this report, and the discussion which followed, appear in another section of this issue of The Journal.

At the last Spring Meeting a report was presented as a result of the united work of the committee of this Society on the standardization of flanges and that of the National Association of Master Steam and Hot Water Fitters, advocating what was called "the 1912 U. S. Standard."

Since that time the Committee of The American Society of Mechanical Engineers through conferences with the Manufacturers' Committee have worked out certain modifications of the previous report and extended the sizes. The new report is in the nature of a compromise in which engineering features relating to strength and safety are maintained, but with concessions in regard to interchangeability of fittings. Objections to the report were raised by several members of the Master Steam and Hot Water Fitters Association during the discussion. Upon motion of George I. Rockwood it was voted to present the matter for further discussion at the Spring Meeting with a view to bringing as many elements as possible into accord in the interim.

After this discussion the Increase of Membership Committee presented its report, which also appears in this issue of The Journal. This shows that 1046 applications for membership were made during the past fiscal year, which is $33\frac{1}{3}$ per cent more than for the year previous. A pleasing event in connection with the subject of membership was the introduction of Amos Whitney of Hartford, Connecticut, eighty-one years old, who had just become a member. Worcester R. Warner spoke feelingly of having been one of

Mr. Whitney's boys forty-five years ago, and of having graduated from the "Pratt and Whitney University."

The discussion of these various reports concluded the business meeting.

PROFESSIONAL SESSIONS

So much time was required for the discussion during the business session of Wednesday morning that the discussion of the first paper of the professional session which followed was only partially completed at the time for adjournment. This, together with the other papers scheduled, was carried over until the session on Thursday morning. Otherwise the program was carried out as intended. The arrangement was such that Thursday afternoon was left free for excursions, and on Wednesday afternoon and Thursday morning there were several simultaneous excursions, all of them well attended and successful.

Following is the list of papers included for the meeting:

Notes on the further Operation of Large Boilers of the Detroit Edison Company, J. W. Parker
Task Setting for Firemen and Maintaining High Efficiency in Boiler Plants, Walter N. Polakov
The Properties of Steam, R. C. H. Heck
Report of Sub-Committee on Hoisting and Conveying
Dynamic Braking for Coal and Ore-Handling Machinery, Clark T. Henderson
Steel Underframe Box Cars, George W. Rink
Steel Upper Frame Box Cars, R. W. Burnett
Cotton Conveying Systems; their Safeguards Against Fire, H. A. Burnham
Specifications for Factory Timbers, F. J. Hoxie
Textile Cost Accounting, C. B. Annett and C. F. Cunningham
Efficiency of Rope Driving as a Means of Power Transmission, E. H. Ahara
Comparative Tests of Three Types of Lineshaft Bearings, Carl C. Thomas, E. R. Maurer and L. E. Kelso
Pitot Tubes for Gas Measurement, W. C. Rowse
Tests of Vacuum Cleaning Systems, J. R. McColl
Tests upon the Transmission of Heat in Vacuum Evaporators, E. W. Kerr
The Art of Enameling or the Coating of Steel and Iron with Glass, Raymond F. Nailler
Gears for Machine-Tool Drives, John Parker
Cast-Iron for Machine-Tool Parts, Henry M. Wood
A Record of Pressed Fits, C. F. MacGill
Standardizing Machinery, Fred H. Colvin
A New Process of Cleaning Producer Gas, H. F. Smith
Present Status of the Large Gas Engine in Europe, Prof. P. Langer
The Fire Hazard in Turbo-Generators, G. S. Lawler
Extinguishing of Fires in Oils and Volatile Liquids, Edw. A. Barrier
Control of Automatic Sprinkler Valves, Fred J. Miller
The Need of More Care in the Design and Construction of Elevated Tanks, W. O. Teague
Fire Pumps, Ezra E. Clark

WEDNESDAY EVENING

At its meeting in Leipzig last June, the Verein deutscher Ingenieure voted to confer upon George Westinghouse, Past-President of the Society, the Grashof Medal, the highest distinction within its power to grant. Its safe delivery to Mr. Westinghouse was entrusted to the Society, and this trust was formally discharged at the session of Wednesday evening, December 3, in the presence of a large audience. Mr. Westinghouse was unfortunately prevented by illness from attending, and the medal was received for him by James Hartness, President-elect.

The Grashof Medal was founded by the Verein in memory of Franz Grashof, and is granted to men who have rendered prominent service in the field of engineering by scientific work or practical activities. Mr. Westinghouse is the third engineer outside of Germany and the first in America to be thus honored. In making the announcement of the award at the Leipzig meeting, Dr. von Miller, president of the Verein, drew attention to the fact that it was not made to Mr. Westinghouse because of the presence of the American Society at the joint meeting, but because of his services for the good of humanity. He spoke also of Mr. Westinghouse's remarkable achievements, the invention of the air-brake, the development of the alternating-current system, and his successful introduction of the geared steam turbine for marine propulsion.

A committee of its members was appointed by the Verein to attend the presentation ceremony on Wednesday evening, consisting of Geheimrath Romberg of Cologne, Herr G. D. Waetzoldt of the German consulate, Col. E. D. Meier, Henry Hess, and Dr. Rudolph Hering; and the three American sister societies, which had been invited to participate, were respectively represented by Charles Warren Hunt, Secretary, Am.Soc.C.E., C. O. Mailloux, President, Am. Inst.E.E., and A. R. Ledoux, Past-President, Am.Inst.M.E.

The meeting was called to order by President W. F. M. Goss, who spoke of the honor conferred upon the American engineering profession in the award to Mr. Westinghouse, and called upon Col. E. D. Meier to give some account of its presentation. Col. Meier described the presentation of the medal at the Leipzig meeting in the presence of a brilliant assemblage, including the King of Saxony and his court, and read a number of cablegrams of greeting and congratulation to Mr. Westinghouse and to the Society.

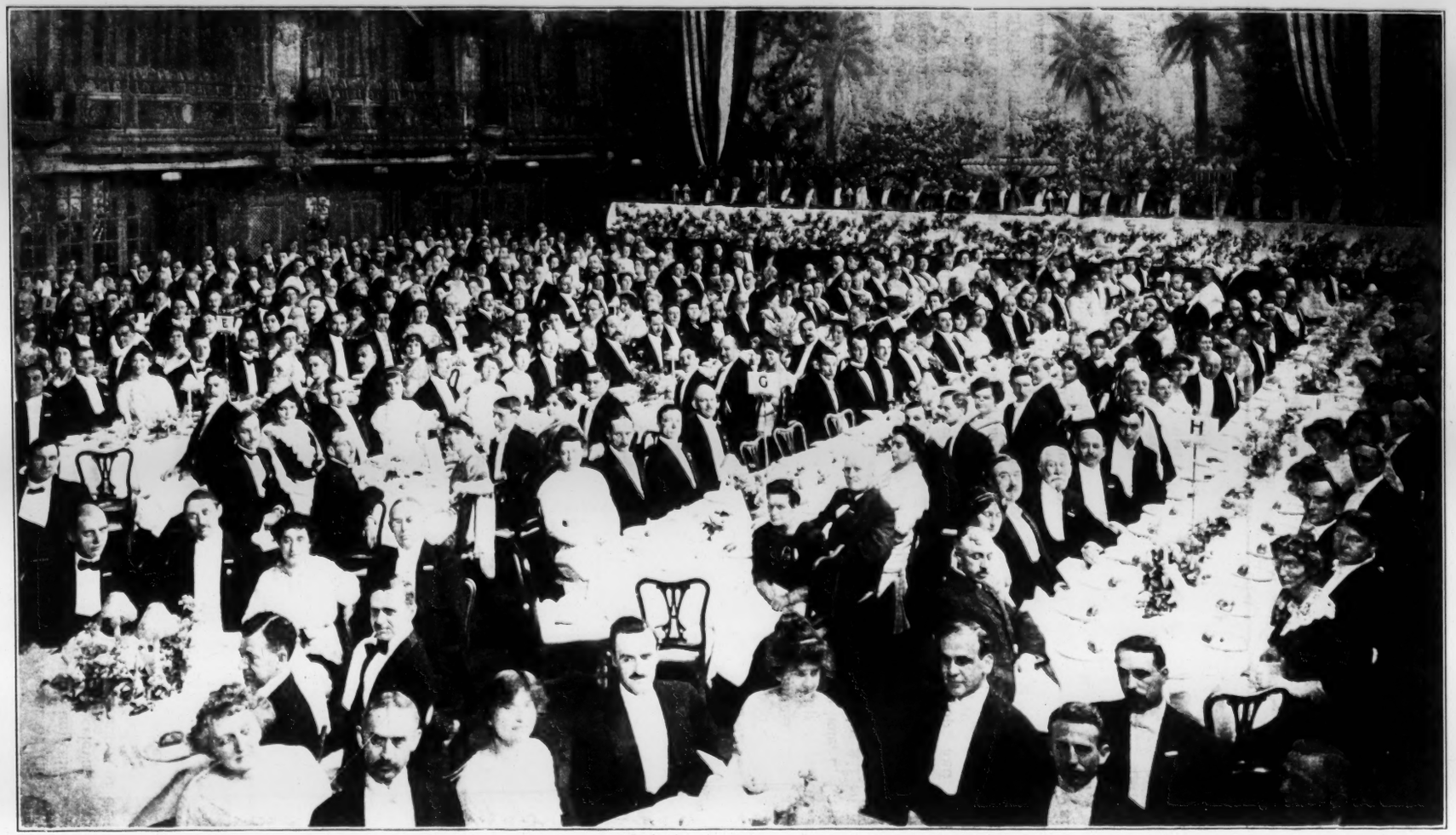
Geheimrath Romberg, acting as spokesman of the Verein, then addressed the audience in German, emphasizing the importance of international meetings among members of the same profession, as a means of bringing nations closer together in a mutual understanding of one another's problems. The Grashof Medal, he said, had been instituted in memory of a man prominent as an engineer, educator and writer, and those to whom it has been granted form a group which it is certainly an honor to belong to.

THURSDAY EVENING'S ENTERTAINMENT

On Thursday evening a German Dinner was held in the Grand Ball Room of the Hotel Astor as one of the features of the usual social evening which has become an institution of the Annual Meeting. Prof. L. P. Breckenridge was the toastmaster of the evening, and the speeches were interspersed between the courses as is the custom in Germany. He was introduced by President Goss, who in turn introduced President-elect Hartness, who gave the results of his observation of industrial Germany, and emphasized the need in this country of greater specialization in our large manufacturing plants.

Col. E. D. Meier explained how the German trip had its inception in the visit of the German engineers who came here three years ago in the interests of the German Museum at Munich. Prof. Arthur M. Greene, Jr., spoke of German education, and said that the researches conducted by the German technical schools had been of great value to the profession largely because of the opportunity afforded for their publication by the Zeitschrift of the Verein deutscher Ingenieure. He was glad to know that through the development of the new Journal of this Society there might eventually be a similar opportunity. Remarks were also made by Sir George Croydon Marks, M.P.

H. L. Gantt said that the German engineer had reached the point which Professor Sweet hoped we some day would reach, for he already realized that the man who knows "what to do and how to do it" is not only the equal but the superior of the man who knows "what was done and who did it."



Group of Members and Guests at the German Dinner held in the Hotel Astor, Thursday Evening, December

The menu and arrangement of the tables at the dinner were almost an exact duplicate of the dinner given in Germany at the Zoological Park in Berlin. The decorations of the ballroom were in German and American national colors, and the arrangement of the speakers' table on the stage was as nearly as possible like the plan used during the entertainment of the American party at Düsseldorf. The background of the stage showed the interior of a conservatory of palms, and was intended to remind the diners of the somewhat similar dinner given in the Palm Garden at Frankfort.

Seated on the speakers' platform were (from left to right): E. E. Keller, Oberlin Smith, Henry R. Towne, Rudolph Hering, H. G. Reist, Calvin W. Rice, A. M. Greene, Jr., Frederick R. Hutton, E. D. Meier, James Hartness, President-elect, W. F. M. Goss, President, L. P. Breckenridge, Worcester R. Warner, Sir George Croydon Marks, M.P., H. T. Clifford, Alex. C. Humphreys, Henry L. Gantt, Henry Hess, Privy-Councillor Fr. Romberg, James Mapes Dodge, William Kent Samuel T. Wellman

He hoped that more of our industrial work could be accomplished in this spirit and by scientifically educated men as it is done in Germany.

Prof. H. E. Clifford showed himself a true genius both by dodging the subject assigned to him by the toastmaster, and by "talking back" to the toastmaster in poetical phrases akin to Kipling and Longfellow. The last toast of the evening, "The Ladies," was given by Secretary Rice.

Something that was appreciated by everyone was the collection of cablegrams read from the various sections of the Verein deutscher Ingenieure at Hamburg, Dresden, Leipzig, Düsseldorf, and Mannheim; from Doctor von Miller, President of the Verein; from the German Museum at Munich; and from Professor Matschoss, who did so much in conducting the party through Germany.

A vivid account of the German trip was given by Worcester R. Warner following the dinner, in which a large number of lantern slides made up from kodak pictures taken by members when abroad and from photographs of historic buildings were used. There were 499 in attendance at the dinner, and over 100 came in later to listen to the lecture, which all greatly enjoyed, and to join in the dance and social time which concluded the evening.

EXCURSIONS

A number of interesting excursions were provided for by the Excursion Committee, John J. Swan, Chairman. An Information Bureau was maintained throughout the meeting and guides appointed to conduct parties to points of general interest, and in addition a number of plants were thrown open, which were extensively visited.

Through the courtesy of the engineering department of the Board of Water Supply, an opportunity was afforded for a visit to two of the shafts and power plants for the tunnel construction work on the Catskill Aqueduct in New York City. Shaft No. 9, at 150th Street and St. Nicholas Avenue, was visited first, and Roger Armstrong, section engineer, and Michael Quinn, superintendent of the Pittsburgh Contracting Company, addressed the party on the engineering features involved and the equipment and methods of excavation. After examining the surface equipment, the party descended into the tunnel and viewed the south heading where the last rock between it and the tunnel to the south had been removed that day. While in that heading, a blast at shaft No. 11, two miles to the south, was clearly felt by the party, and before they left the tunnel the smoke of the blast came upon them, giving them some idea of the conditions under which actual tunnel operations are pursued. The underground magazine for the storage of 1000 lb. of explosives was also shown to the party. The party then proceeded to shaft No. 12, at 106th Street and Central Park West, where an opportunity was had to view the finished tunnel work, the concrete invert having been completed in the south tunnel. The party was conducted by John R. Healy. A group of the membership also visited the Kensico Dam in Valhalla, which is now approaching completion, under the guidance of F. v. D. Longacre.

A visit to the new Woolworth building, the highest office building in the world, was attended by about forty members and guests. By permission of E. A. Cochran, superintendent of the building, the entire power and mechanical plant of the building was thrown open for inspection and much interest was manifested in the elevators and their safety appliances, the fire protection and water supply system, which owing to the height of the building is divided into several levels, the highest imposing a pressure of over 300 lb. on the pumps; and the elevator equipment, where the traction type of elevator machines of the Otis Elevator Company are used, which are especially adapted for high-rise service. There are 26 passenger elevators of this type installed in the building, two of which rise to the 51st story of the tower, a rise of 679 ft., the highest travel for a building elevator in the world. Furthermore, the six express elevators operating in the tower, are the highest speed building elevators in existence, being designed to operate at a speed of 700 ft. per minute. These elevators are protected from danger in falling by the air cushion method, the lower portion of each shaft being enclosed and heavily strengthened to serve as an air cushion. The party was guided by H. R. Cobleigh.

The opportunity for an inspection of the new Grand Central Terminal of the New York Central and Hudson River Railroad attracted a large number, and through the courtesy of Geo. W. Kittridge, Chief Engineer, guides were appointed who conducted this party through the new passenger station, the yards, the heating plant, and the lighting sub-station, and explained the operating details of the new terminal. For the complete presentation of the many interesting details of the great terminal, a 16-page pamphlet, entitled The Mechanical, Electrical, and Sanitary Equipment of the Grand Central Terminal, had been prepared especially for this convention and was distributed to the members of the party and at the meetings. The party was conducted by Carl Schwartz.

The arrangements made by the Hamburg-American Line for an inspection of the second largest vessel of its fleet, the Kaiserin Augusta Victoria, next in size to the Imperator, were taken advantage of by about 70. The party was taken throughout the ship from the captain's bridge down to the steerage and stoke hole, including a visit to the engine room, and was conducted by Alfred E. Kornfeld.

A party of about 200 visited the United States Navy Yard in Brooklyn, under the guidance of J. J. Swan. Commander Hardy, assisted by other officers, conducted the visitors throughout the shops and yard, and through the courtesy of O. P. Jackson, Commander U. S. N., and Chief Engineer Fisher, of the battleship, the party were allowed to inspect the U. S. S. North Dakota, which is representative of the latest construction in modern battleships.

The following plants were also visited: the high-pressure pumping stations of the City of New York; the Waterside stations of the New York Edison, W. W. Macon, guide; the 59th Street power station of the Interborough Rapid Transit Company, Alfred Noble, guide; the E. W. Bliss Company, Brooklyn, H. G. Goss, guide; the hydraulic works of Henry R. Worthington, Harrison, N. J., H. G. Goss, guide; the paper mill of the Tidewater Paper Company, Brooklyn, W. W. Macon, guide; and the Davis-Bournonville Company, Jersey City, N. J., N. B. Payne, guide. The two latter plants were visited for the first time at an annual meeting. At the Tidewater Company the manufacture of newspaper stock from pulp to finished paper was shown, and at the Davis-Bournonville plant the visitors had the opportunity of seeing the rebuilding of a broken tooth in a gear wheel, a demonstration of fire emergency equipment, and the cutting through of a section of armor plate with the oxyhydric torch, and other interesting exhibits.

EFFICIENCY IN TECHNICAL EDUCATION A FACTOR IN THE DEVELOPMENT OF PROFESSIONAL IDEALS

BY W. F. M. GOSS, CHICAGO, ILL.

President of the Society

FIFTY-ONE years ago, the Congress of the United States passed an act providing for the establishment of colleges in each of the several states of the Union.[1] The passage of this so-called Land Grant Act, more than any other single event, constitutes the foundation of technical education in the United States. It aided in the establishment of the Massachusetts Institute of Technology, of Cornell University, and in due time of colleges or universities offering engineering courses in every state. Many states were slow in proceeding under this act and some, which to-day have flourishing universities, had not then been admitted into the Union. As a consequence, technical education, as a national movement, did not have its beginning until the early seventies, or approximately forty years ago.[2]

The coming of the technical school, whether as a department of the state university or otherwise, was not in any large sense the result of active interest on the part of engineers. It came as the unfolding of an educational movement inspired and sustained by scientists and educators.[3] It came as an expression of a nation's desire to emphasize the importance of science in its relation to the every day work of mankind. It came when our country's engineering industries were young, when engineering practice was guided by precedent rather than by mathematical analyses, and when those who were skilled in leadership were also skilled in the manipulative processes of their art. It came when the industries offered few inducements to a young man whose chief claim to their attention was the fact that he had studied books, and when the limitations of the employer often made it difficult for him to appreciate the qualifications of such an applicant. The practical men, therefore, expected the new school to train its students in practice rather than in theory, to do things rather than to know facts; they looked to the school for a preparation which should be kinetic rather than potential.

The technical school was not unsympathetic to this expectation. It gave early evidence of a desire to meet the reasonable demands of those to whom its graduates must go. It gave generous attention to courses in shop practice, in field work, in drawing, and in designing. It introduced certain text-book courses, largely descriptive, and in many other ways it emphasized the more practical aspects of the engineer's work. By so doing, the school met an immediate need, gained for technical education the good will of the leaders of industry, and laid the foundations for a degree of popular support, which, in process of time, transformed the simpler beginnings of nearly half a century ago into one of the world's greatest undertakings in higher education.

But, in giving their response to the immediate needs of the industries, the early leaders in technical education rarely lost sight of the possibilities of science as a means to the development of correct theory. Under the guidance of such men as Rogers, Runkle and Thurston, the art of the teacher was so combined with processes common to practice, that even training in practical things became an important educational influence. Shop courses and drawing courses became new expressions of an educational function. The study of things practical was put upon so high a plane that the attention of the student was secured, his power of observation increased, his view broadened and all his conceptions stimulated. Moreover, while admitting courses of a practical nature, the early leaders in technical education did not limit their scheme of instruction to such courses. They construed the federal law liberally. They utilized the popular interest in more simple applications of science as an argument for the encouragement of work in more complex fields, and, as the usefulness of the men trained under these leaders became more and more apparent, an extension of their plan of work became possible. Courses of

[1] This "Land Grant Act," sometimes referred to as the "Morrill Bill," in honor of Representative, and afterwards, Senator Justin S. Morrill, of Vermont, who labored through several sessions of Congress to secure its passage, was signed by Abraham Lincoln, July 2, 1862. It granted to each state in the Union 30,000 acres of land for each senator and representative to which it was entitled in the Federal Congress, for the purpose of promoting "the liberal and practical education of the industrial classes in the several pursuits and professions in life." It has recently been referred to by a distinguished educator as "the greatest endowment of higher education ever made at one time by the act of any legislature."

[2] This statement does not disregard the fact that engineering education under private auspices began earlier than indicated. The Rensselaer Polytechnic Institute was founded in 1824, incorporated in 1826, and reorganized under its present name in 1849.

[3] In connection with this statement it will be of interest to note that President Edmund J. James of the University of Illinois, in a paper entitled "The Origin of the Land Grant Act of 1862," has shown that Jonathan B. Turner, at one time professor in Illinois College at Jacksonville, Ill., deserves the credit of having been the first to formulate clearly and definitely the plans of a national grant of land to each state in the Union, for the promotion of agriculture and the mechanical arts, and of having organized and continued to a successful issue, the agitation that made possible the passage of the bill.

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instruction were extended. Descriptive work gradually gave way to work which was more mathematical. Great laboratories for instruction and research were established, until the American student finds at home educational facilities for which he formerly went abroad.

Meanwhile the every-day citizen, who is the normal supporter of the great state university, is coming to understand something of the breadth of the educational problem which is presented by the activities of the technical school. He has seen the number of its students multiply, and its graduates become leaders in the work of great industries. Questions affecting the support of the technical school have sometimes appeared as political questions, and in his discussions of these the normal citizen has not been found lacking in his appreciation of the technical school. Engineering education now suggests something more to him than a class-room. He understands that efficient instruction must find expression in the applications of science and in the promotion of scientific research. These are important conceptions, and the fact that they are entertained by the public suggests the great influence already exerted by the technical school.

The American technical school stands today on the threshold of great achievements. Its pioneer days are nearly over. The fruitage of two generations of educational effort is now in evidence. Captains of industry no longer look in doubt upon the technical graduate; they give him work. Public confidence in the new education has been won and its permanent support is assured. What of the future? To what new attributes must the technical school give expression and what new responsibilities should it assume? These are questions which today confront the school, and they are questions also in which the membership of The American Society of Mechanical Engineers may well be interested, for the technical school and the professional society are partners in a common cause.

An attempt to outline the problems of the technical school must recognize the fact that great advances in any art or profession await the coming of great men. The modern need in the field of engineering is for men who can perform the exceptional task; for men who are safe keepers of their brothers' interests; for men whose qualities of character are so sound and strong that they instinctively perceive the way of truth and follow it; for men whose activity and understanding detect the defects in established practice and find a way to improve that practice; for men who so well understand the fundamental principles of science as to be able to predict the effect of the next step before it has been taken; for men, in fine, who can rank with the world's great leaders in science and industry. I conceive it to be the prime purpose of the technical school to make its contribution toward the development of such men.

It would seem unnecessary to remind an audience of professional engineers that the achievements of the technical school center in the quality and strength of its instructional staff. The present-day need is for increased strength of staff. All honor is due the fine coterie of men who, undertaking the work of the technical school a quarter of a century or more ago, have adhered to their task in the face of discouragement at great personal sacrifice and with a spirit that has been fine and even heroic. But retrospect, however satisfactory in itself, will not solve our future problems. Great leaders in the work of the technical school are few, and the unfortunate fact is that throughout the years that are past few men have been in training where the service now demands many. There are many reasons for this. An important one is to be found in the limitations which have been put upon the salary budget. The man who builds great bridges or who directs the activities of a great industry, is none too gifted to guide the efforts of ambitious youth, and hold before the student large ideals of life. And yet, in the industries a man may receive in a month an amount equivalent to the annual salary of many college professors. It is clear to all who know the field that while the school must suffer some years to come, through its deficiencies in the past, a new policy should be entered upon as speedily as possible. It should be expressed in such terms as will convince the exceptional man, looking for a career, that it will be worth his while to prepare himself by study, by professional practice, by travel, by activities as a scientific investigator, by every process which can develop and broaden, for a life-work as a member of a college faculty. Few among American technical schools can today offer professorships which in themselves are sufficiently attractive to justify a young man in securing for himself so elaborate a preparation. The remedy cannot ordinarily be applied by the college itself; it must come as the result of interest shown at the sources of financial supply. In the great state universities it must be the result of public appreciation of the need; you, I know, will realize that public appreciation, though a plant of slow growth, may be cultivated by many different agencies.

Not only is it required in the interest of higher efficiency that the American technical school have an instructional staff of the highest possible quality, but it is also required that such a staff be not overburdened with routine duties. The American youth is greatly influenced by the personality of his instructor. While the exceptional student will view his problems broadly, will add his own personality to that which the professor gives and thus work out large and vigorous conceptions, the normal student is as a disciple following a master; he admires the master's skill, he thinks in terms of the master's thoughts and is very likely to be influenced by the master's limitations. If the engineering graduate sometimes degenerates into an animated slide rule, may it not be possible that he has been instinctively led to such a career through ill-conceived

tread-mill processes in the class-room? If so, the remedy is to be found in reforming the work of the class-room, and one sure road to such a reform is that which opens the way whereby men of large caliber may have time in which to impress themselves upon their students. The technical school is greatly in need of simple living and high thinking. Simple living is easily attained unto, but high thinking, in its essence, involves a certain element of leisure, or perhaps freedom in the choice of one's occupation, which after all, is but another term for leisure, and no atmosphere surcharged with high thinking can prevail on a campus where every individual student and professor is perpetually keyed up to concert pitch in an endeavor to accomplish an assigned task. This is a matter in which our English and German neighbors can, by the trend of their procedure, disclose much which will be serviceable to the American technical school.

The importance of superior leadership in the school is emphasized by the fact that the attitude of the American student reflects rather faithfully the changing spirit of the times. His parents in their home, though perhaps living unpretentiously, no longer pursue the quiet and simple ways of former days. They have their part in the complexity of the modern business and social life. It is not surprising that their son, the student of today, finds some difficulty in settling down to the quiet routine of the cloister. He is more likely to combine with study the social and athletic activities of the college. The encouragement of fellowship with men, as well as of study, is in fact recognized by the school authorities as a legitimate function of the university. The danger appears in a disposition on the part of students to segregate their activities, to regard their study as work and their athletics as play. Comparisons growing out of such distinctions are to the disadvantage of the student's occupation. The habit of placing the emphasis continually on the joy of the play, prevents him from feeling the joy of the more intellectual pursuits and it encourages half-hearted study. It is here that masterful leadership in the classroom will assert itself. The joy of scholastic achievement is best made plain by the introduction and maintenance of inspiring views depicting the meaning of a life of service coupled with the conception that student days are part of such a life; that student days are not merely a preparation for life, but that they are life.

Masterful leadership eliminates entirely the feeling once entertained by the students, that the instructor is a taskmaster, and that to be obedient to him, the student must perform the task. The great teacher, freed from the burden of excessive routine, may easily recognize differences in ability and will encourage the student who must plod and inspire to unusual performance the brilliant student who knows no limit to his achievement save his physical strength.

Assuming the technical school to be in possession of an ideal instructional staff, the way will open for progress through many channels of secondary importance. It is altogether possible that in our present-day routine too much time is given to things which are simple. Much that is now studied may perhaps be read. The habit of studying intensely a few books to the entire exclusion of the great mass of historical and biographical engineering literature affords the student but little opportunity of acquiring a habit of rapid and intelligent reading, which in itself is an accomplishment worth striving for. The practice of the shop laboratory, the drawing-room, the surveying field and the study of descriptive texts, rightly interpreted, are important adjuncts in the training of the engineer, but the time has ceased to be when such activities constitute the chief characteristics of the technical school. Year by year the technical school has increased the emphasis given to processes which are mathematical. The progress of the next decade will be seen in the thoroughness with which high standards in such work are accepted and advanced. The intensive work of the course must be based upon fundamental theory, and the fields to which such theory is applied must be broadened. The engineering graduate is no longer required to be prepared to operate machines, but he must have a well-trained mind and he must possess power to perfect his qualifications along any specialized lines in the shortest possible time. To this end, the years in college must be spent in acquiring an understanding of principles and in the development of those aspects of theory which are difficult to acquire after one's college days are over.

The aspirations of many students will not be satisfied by the possibilities of a four years' course, and for these graduate work must follow. In making this assertion I do not forget that in this country graduate work in engineering has thus far received but little attention, but this is due rather to our immaturity than to the fact that we do not recognize its need. The time is at hand when the services of the scholarly engineer, the man who through his perfect command of fundamental theory can visualize a cause from its effects, will be in great demand. The manufacturing industries, the great commercial laboratories of our country and the colleges themselves are in need of men who have done more work than any one can accomplish in the normal four years of a college course. The problem of graduate work in engineering is therefore a national one, and it is worthy of note that a number of universities and technical schools are now holding before the public visions of its value.

The American technical school has already accomplished much in the development of laboratories. While it has used them thus far chiefly as facilities for instruction, it has always recognized the fact that there are other and equally important functions to be performed by them. The laboratories of a considerable number of schools have made important contributions

to the sum of human knowledge. This fact is suggestive of future possibilities. The practice of men must be guided by facts. The technical school cannot content itself with routine service. It must enshroud its classroom and its laboratories with an atmosphere of scientific achievement; its professors should be leaders not only as classroom instructors, but nation-wide leaders, even world-wide leaders in the complex and highly diversified fields of the science which they represent. The laboratories available for the use of such men should multiply. Every technical school should aid, as individual schools have already aided, in setting forth new interpretations of physical phenomena. The laboratory must be more than a shop, more than an engine room, more than a collection of testing machines. No great laboratory can be ordered ready-made. It cannot be produced in response to a decree. Whatever its dimensions or its cost, it can be great only in so far as it reflects a purpose which is scientifically sound, and employs means which are scientifically correct. Its significance is necessarily limited to the qualities of the men who create and operate it. A laboratory which has been evolved through the activities and desires of a master is not only priceless for the school that possesses it, but necessary as a source of information of the highest value, to the field of practice which it is designed to serve. The chief engineer of a great railway system, in writing of the work of a certain college laboratory, has recently certified in terms which are clear and emphatic, to the value of principles affecting the design of certain structures which had been developed by the laboratory, and extensively used by the corporation which he served. Illustrations of similar import will occur to all readers of technical literature. Assuming that the country has need of research laboratories for purposes quite apart from the work of instruction, it can, I think, be shown that the technical school constitutes the most promising agency in our national economy upon which to place the responsibilities incident to their creation and maintenance.

In concluding this phase of my discussion, I must not fail to recognize the contributions of members of this Society to the upbuilding of the American technical school. I do not forget that some of our members are university, college or technical school professors; that others are presidents, and still others are officers or members of administrative boards. They will readily understand, however imperfect my language, the significance of the matters which I am endeavoring to emphasize. To those of you who have a lay interest only in technical education, let me suggest that you do not always time your visits to your Alma Mater to make connection with a great football game or a great baseball game, but that you make some visits at a time when you can show interest in the academical progress of the student body; not because the game is unworthy, but that you may secure some understanding of the students' achievements in severely scholarly efforts, which after all is the measure by which the success of the school must ultimately be judged.

The relation existing between the standard of instruction in schools which prepare for a profession and the ideals of the profession have already been suggested and in their general aspects are obvious. The fact that educational institutions of high standing are sending out each year into the engineering pursuits of our country more than 2500 graduates, nearly 1000 of whom enter the field of mechanical engineering, suggests the basis for this relationship. The technical school is, in fact, recruiting and otherwise stimulating the engineering work of the country. Its more important contributions may be summarized as follows:

First, the work of the school tends to emphasize the dignity of the calling. Professionalism as distinguished from the art or practice of engineering is after all a question of quality. Professionalism is breadth! In our ambition to have a large part in the world's affairs we sometimes forget the fundamental source of power. We sometimes think too much of honors and too little of service; we desire the position before we are qualified to discharge the responsibilities it imposes. Our strivings must be for fitness. Progress in advancing the ideals of our profession will depend upon the character of the service rendered by the members of the profession. If every practitioner in the field of Mechanical Engineering possessed character and ability responding to our highest ideals, no one would question the right of mechanical engineers to regard themselves members of a profession. The technical school makes its contribution to the upbuilding of professional ideals by sending trained men into the profession.

Second, a service which the technical school is rendering the profession of engineering is that of contributing to the sum of its scientific data. Engineering as a science has made progress by leaps and bounds; rule of the thumb has given way to the rule of the mathematician. But notwithstanding all that has been accomplished in his direction, there are as yet but few departments in the field of mechanical engineering in which the basis of design is actually perfected. Further progress awaits the establishment of facts concerning such matters as the behavior of constructive materials, of lubricating films, of combustible mixtures, and of liquids and gases employed in thermo-dynamic processes as vehicles for the transmission of heat. The American engineer who has hitherto been occupied with the so-called practical aspects of his profession has concerned himself less than have the engineers of the great empire across the sea, with the work of the scientist. We, as engineers, need to train ourselves to a condition of mind which will make studious processes less difficult than at present. Along this line of endeavor the researches of the technical school will aid the profession by establishing new standards of pro-

ficiency, and by making new contributions to the existing fabric of facts.

Third, an important contribution which the school is rendering the profession of engineering is that of emphasizing the profession's unity of purpose. The college graduate has had at least four years' training in teamwork. A majority of the student organizations with which he has been associated has maintained extra-mural affiliations. The college fraternity, the college Y. M. C. A., the college athletic activities would lose much of their significance if their whole thought and action were restricted to the home campus. In intercollegiate contests the desire is not in any large sense to win over a neighbor, but to win as an achievement. A graduate of Wisconsin finds a friend when he meets for the first time a graduate of Illinois, and a member of the faculty of one institution, upon a trip of visitation to a neighboring institution, is sure to find himself among those who cheer and stimulate him. This intercollegiate spirit of fellowship has become a national asset—it persists when the day of graduation has passed. It represents a spirit which, in the business and professional world, conserves and upbuilds. It is working out the world's great problems of mutual respect, of mutual help and of concentration of purpose. In the development of our future ideals and practices, tradition and prejudice are likely to play a steadily diminishing part, and the spirit of fellowship, inherited from college days, a part of steadily increasing importance.

Whatever may be the nature of the contribution of the technical school to the ideals of the profession, the extent of the contribution is a function of the quality of the school. Better instruction in the school must supply better recruits for the profession, greater activities in scientific researches on the part of the school must operate to increase the facility with which the problems of the engineer are solved, and influences in the school which tend to extend the student's horizon and broaden his sympathies, will in due time make their impress upon the professional life outside of the school. That is, efficiency in technical education is a factor in the development of professional ideals, and hence a matter of prime importance to this society, as well as to all other organizations of engineers. I have presented this discussion because I believe that the problems of the technical school should not be left to the school master, for, broadly interpreted, they are not the problems of the school but the problems of the profession. As such they should, I believe, receive painstaking and persistent attention from this and other engineering societies.

The Grashof Medal presented to George Westinghouse by the Verein deutscher Ingenieure at Leipzig, June 1913, and formally transmitted to Mr. Westinghouse by The American Society of Mechanical Engineers at the Annual Meeting, December 3, 1913

TEXTILE SESSION

PAPERS CONTRIBUTED AT THE ANNUAL MEETING BY THE SUB-COMMITTEE ON TEXTILES

COTTON CONVEYING SYSTEMS: THEIR SAFEGUARDS AGAINST FIRE

By H. A. Burnham, Waltham, Mass.

Member of the Society

The purpose of this paper is to describe briefly methods of limiting the number and extent of fires such as occur from known causes in cotton mills in connection with the preparing processes of opening and picking. Such fires form from 50 to 75 per cent. of all the cotton mill fires reported. The particular point in these processes to which attention is directed is the mechanical arrangement of the conveying apparatus used for transferring the cotton from the bale opening room to the picker room.

The methods described are the results of the experience of many of the best known cotton mills in the northern and southern states, whose co-operation with the Associated Factory Mutual Fire Insurance Companies has been instrumental in developing this class of apparatus along the present lines of greatest safety and efficiency. There are records of many instances in which, by the observance of the simple precautions described, troubles from fire formerly occurring with great frequency and regularity have almost entirely disappeared.

The usual machinery for the above work consists of:

a A bale breaker or opening machine having a spiked apron moving at moderate speed at the rear of a square iron hopper, which is fed by hand or by a mixing apron with lumps of cotton from the bale. This machine loosens up the matted cotton, allowing any heavy foreign substance to drop out, and delivers the loose cotton uniformly to the conveyor. The general appearance of this machine is shown in Figs. 1 and 2.

b The conveyor, either pneumatic or mechanical, or both, carrying the loosened cotton to the picker room. Fig. 2 shows the feeding-in end of a pneumatic conveyor, and Fig. 4 shows a mechanical conveyor.

c The pickers which have hoppers and feeding rolls to deliver the fiber to iron casings containing rapidly revolving metal beaters. The latter, with the assistance of air currents, separate the fiber from the dust. A line of these hoppers being fed by a mechanical conveyor, is shown in Fig. 4, and another line in Fig. 3, without any feeding mechanism.

As fires are almost sure to occur if heavy foreign material or matches enter the pickers or the fan of a pneumatic conveyor, it is important that all such material be removed at the bale breaker or before it is reached and that the various parts of the conveyor be properly arranged.

None of this foreign material is more difficult to remove than matches, as they weigh too little to separate readily from the cotton by ordinary means. In this matter more than in any other, preventing the matches from entering the stock is the only true solution of the problem. This has been actually accomplished in some mill properties by providing the help with safety matches to the exclusion of all other kinds.

PNEUMATIC CONVEYORS

The pneumatic cotton conveyor as it exists to-day is the outcome of attempts made in earlier days to save the labor of trucking baled cotton from the storehouse to the picker room. Mills having storehouses separate from their manufacturing rooms, and especially the larger mills, found this labor a considerable item.

At that time it had been common practice to convey damp cotton from dye house to drier by blowing it through a long sheet metal pipe attached to the discharge outlet of a pressure blower, the stock being fed in through the suction inlet of the blower (see *a*, Fig. 5). In applying this method to dry cotton fed by hand, however, fires in the blow pipe were common, and the air blast made them so intense that the arrangement in this crude form was considered far too risky for general use.

In many kinds of work the action of the air on the cotton in transit was found to be beneficial to subsequent working of the cotton; so much so, indeed, that manufacturers who had not at first thought it worth while, wished to use the blowing system.

The causes of these fires were found to be foreign substances in the stock, such as bits of iron, stones, or matches which had been carelessly dropped, or the wedging of the cotton in the fan casing due to the feeding in of masses which were too large to pass through. In some cases this fault was aggravated by the too small clearance in the fan between the blades and casing.

The number of fires with this arrangement was considerably reduced in some cases by using blowers

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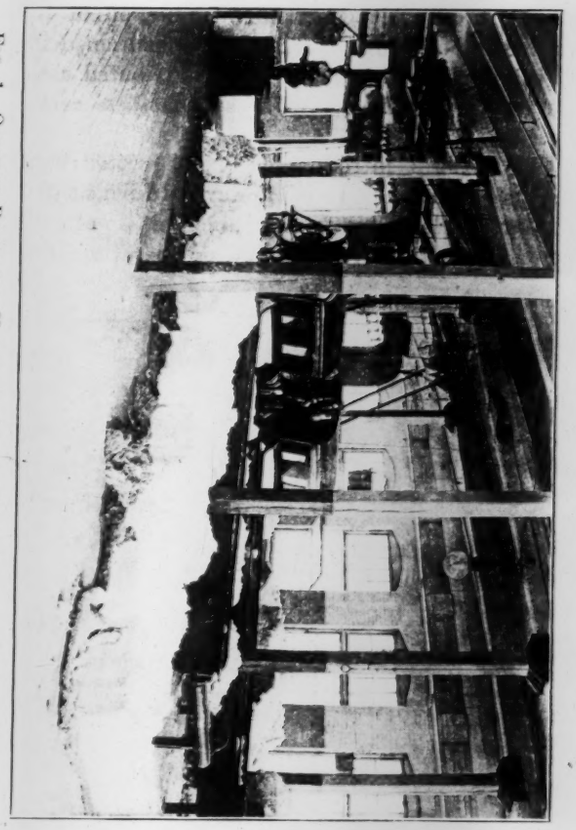


Fig. 1 Opening Room for Handling Large Quantities of Cotton Fed by Hand from the Bales to the Aprons

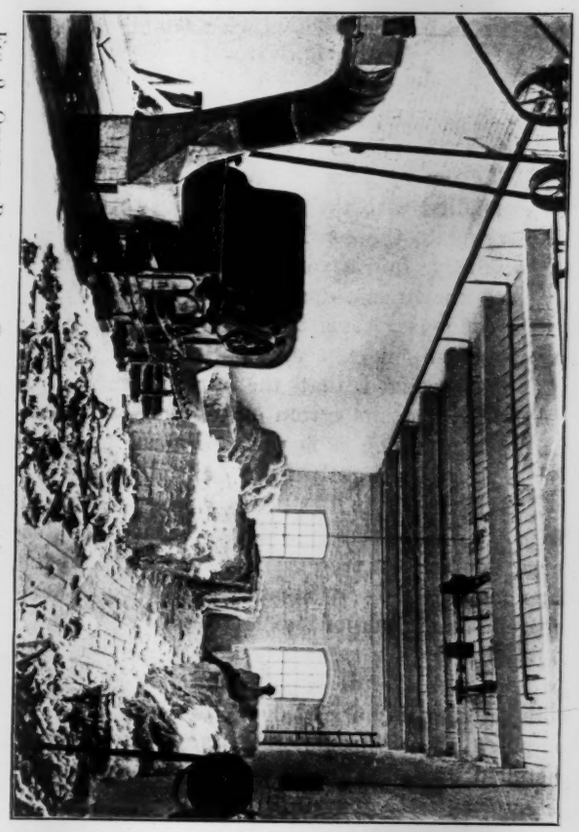


Fig. 2 Opening Room with Bale Breaker Delivering to a Conveyor Pipe under Suction, with Box to Catch Heavy Material

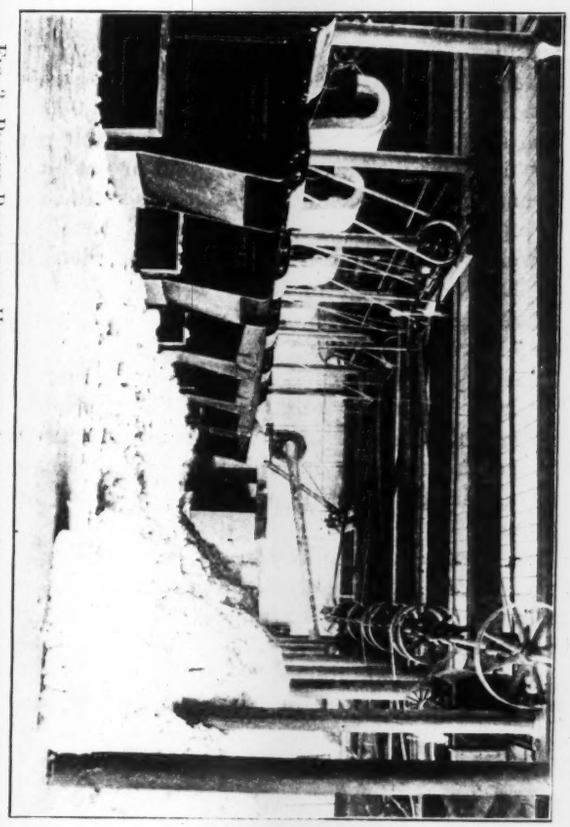


Fig. 3 Picker Room with Hoppers of Automatic Feeders Filled by Hand from Piles Fed from Condensers Above

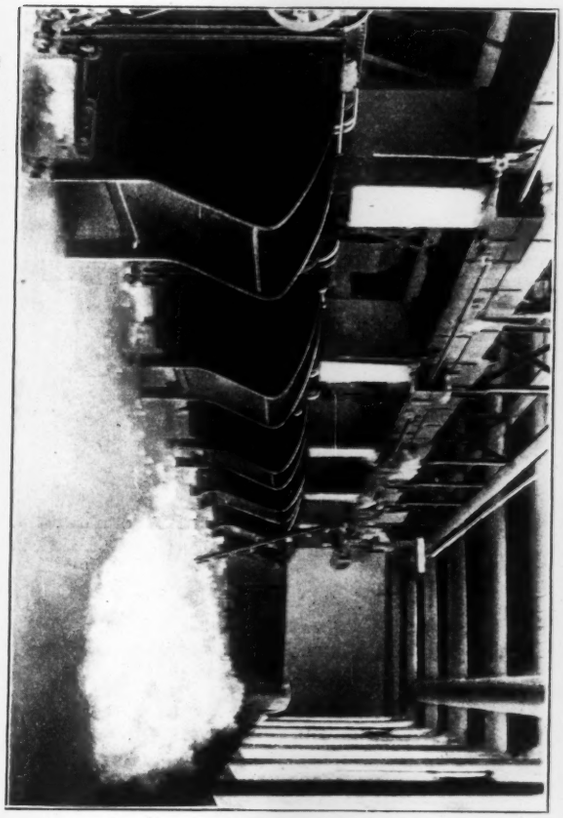


Fig. 4 Picker Room with Hoppers of Automatic Feeders Filled by Overhead Modern Mechanical Conveyor

having bronze blades. The introduction of the bale breaker or opening machine above mentioned in place of the irregular hand feed also contributed materially toward the elimination of fires from these causes (see *b*, Fig. 5.)

The general introduction of the cotton condenser in its improved form, however, furnished means for avoiding the objectionable blast of air and cotton in the bin or room, and of operating the entire

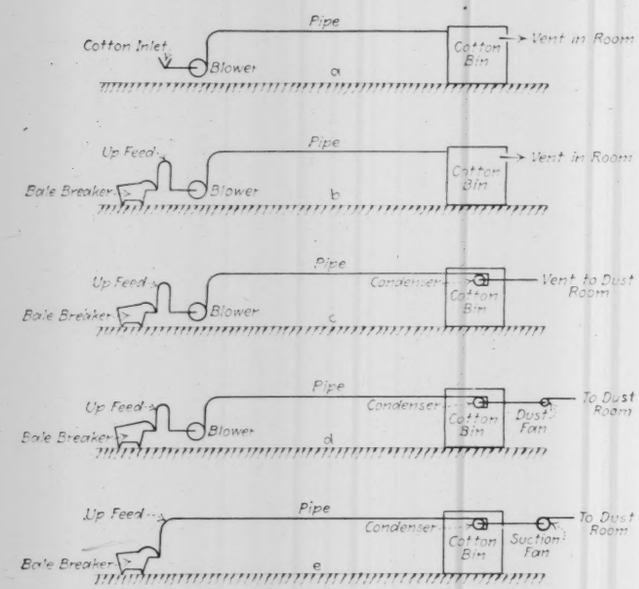


FIG. 5 DIAGRAM SHOWING DEVELOPMENT OF SUCTION SYSTEM OF PNEUMATIC COTTON CONVEYOR

system under suction instead of under pressure. This advantage of operating under suction entirely, however, was not at once recognized, and many systems were installed with the stock blowing through the fan discharging to the condenser (see *c*, Fig. 5), or with an auxiliary fan beyond the condenser smaller in size, and known as a dust fan (see *d*, Fig. 5).

The condenser consists of a slowly revolving cylindrical screen in a casing, with air pipe connections so arranged that the air current in passing through it, deposits cotton on the outer surface of the screen from which it is removed by a small roll, the cotton dropping lightly from this roll.

The final step to the present practice was to eliminate the blow fan, and to make the dust fan large enough to produce the necessary air current, thus making the cotton-carrying part of the system entirely under suction (see *e*, Fig. 5).

By placing the condenser and the cotton inlet both on the suction side of the fan, as in Fig. 5 *e*, or both on the discharge side of the fan, as in Fig. 10, no stock passes through the fan, and with systems so installed fires are a rare occurrence. For convenience in reference, the former is termed "Suction System" and the latter, "Pressure System."

SUCTION SYSTEMS

Under the most favorable conditions, pneumatic systems operated under suction have successfully handled through pipes up to 900 or 1,000 feet in length, quantities up to 4,000 lb. of cotton per hour. The limiting distances and weights of cotton are determined by local conditions such as size and tightness of pipes, number of bends, uniformity of feed, and adjustment of air passages through the condenser.

The sketch, Fig. 6, shows a modern safe cotton-conveying system taking cotton from an opening room through a suction pneumatic conveyor and delivering through a condenser upon a mechanical conveyor by which the cotton is carried to various points. This combination represents the best modern practice in the larger mills. In mills handling various staples, the discharge is often into bins instead of into machines.

In planning a new system for cotton conveying and distributing, or in remodelling an old system, the following conditions in the relative arrangement of parts should be approached as closely as possible in order to eliminate unnecessary fire hazards:

(*a*) *Removal of Foreign Substances.* Provision should be made for heavy substances to drop out of the stock before en-

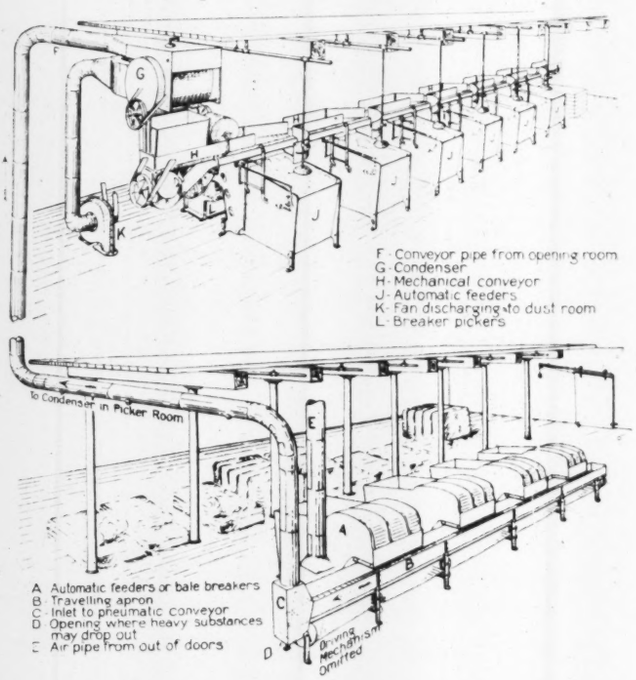


FIG. 6 SUCTION PNEUMATIC SYSTEM TAKING COTTON FROM AN OPENING ROOM AND DELIVERING TO A MECHANICAL CONVEYOR FOR DISTRIBUTION

tering the conveyor pipe. This can be done by having the cotton pass vertically upward into the conveyor pipe, shaping the inlet like an inverted funnel or box

over the feed table or apron, and making the vertical part of the pipe about 12 ft. high (see Fig. 6). To obtain the desired vertical height it is sometimes necessary to use a long radius inverted U.

(*b*) *Location of Fan.* The fan should be so located that no cotton will pass through it. In cases of extreme length this condition can be met by installing two separate systems in series with a relay station at which the condenser of the first system discharges to the inlet of the second.

(*c*) *Disposal of Air Vents.* Air currents from the system should not discharge into the main rooms. This condition is usually met by discharging the air direct to the dust room.

(*d*) *Location of Pipes.* Long pipes should be generally located outside of main rooms and should not pass through important fire walls or floors. Trouble from condensation inside the conveyor pipe in cold weather, which sometimes arises, may be avoided by providing an auxiliary cold air inlet (see *E*, Fig. 6), and in difficult cases by covering the conveyor pipe, where out of doors, with non-conducting covering.

(*e*) *Pipes* should have joints riveted in addition to being soldered and have suitable handholes for cleaning. This is to guard

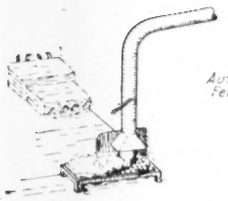


Fig. 7 Arrangement in Opening Room with Mechanical Conveyor Omitted

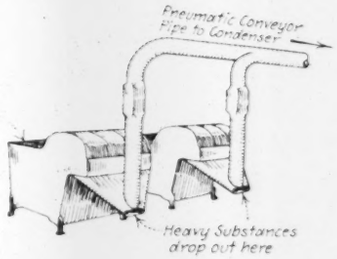


Fig. 8 Arrangement in Opening Room with Bale Breaker Omitted

against breakage of the pipe in case of fire from inside or outside the pipe.

VARIATIONS IN ARRANGEMENT

Variations from the arrangement shown in Fig. 6 are frequently necessary, depending on the number of varieties of stock, the quantity, quality, and distance to be carried, as follows:

(*a*) *Omission of Bale Breaker.* In the opening room of the smaller mills, the bale breaker or automatic feeder is often omitted and the cotton fed from a pile previously shaken out by hand from the bale. In this case the stock should be fed across a slatted movable table under the inverted cone of the inlet pipe (see Fig. 7). Uniform hand feed, however, is difficult and without the automatic feeder, frequent clogging of the condenser may result.

(*b*) *Omission of Mechanical Conveyor in Opening Room.* In some of the older systems or where more than one pneumatic conveyor is to be fed, the mechanical conveyor in the opening room is sometimes omitted by forming a pipe connection be-

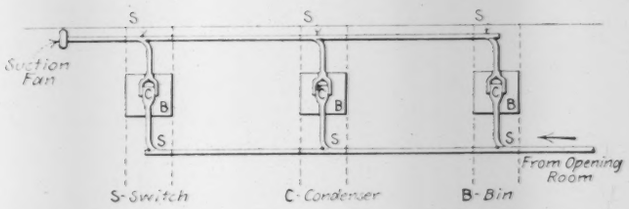


Fig. 9 Plan showing Arrangement in Picker Room with Mechanical Conveyor Omitted

tween the automatic feeders and the branches to the conveyor pipe. In such cases this connection may be in the form of a flattened conical pipe sloping downward and having an opening at the lowest point opposite the upward turn where heavy material may drop out (see Fig. 8).

(*c*) *Omission of Mechanical Conveyor in Picker Room.* At the picker room end, in case several staples are used, the mechanical conveyor is often omitted and the cotton delivered direct to bins through condensers. Under these conditions the condensers may be piped in parallel with proper switches and the same fan used for all (see Fig. 9).

PRESSURE SYSTEMS

In handling cotton mixed with some wool, as in knitting mills, felt mills, or colored cotton mills using a large variety of colored stock, pneumatic systems are usually operated under pressure instead of suction. The reasons for this are, that (*a*) stock containing above a small percentage of wool cannot be successfully handled with condensers, the greasy nature of the wool causing it to stick and clog the mechanism; and (*b*) in handling colored cotton the bins are often so small and numerous that the use of a condenser for each is impracticable. Mechanical conveyors are also objected to by manufacturers for handling colors on account of the liability that small tufts of stock caught in the mechanism will afterward find their way into lots of another color.

The pressure system improperly installed is dangerous to life and property, as the strong blast of air intensifies any fire in the pipe or near its outlet. The safest arrangement of such a system is obtained by observing the conditions already stated regarding

location and construction of pipes for suction systems, and also the following conditions:

(*a*) *Location of Fan.* With a pressure system, both the inlet and outlet for the stock should be placed on the discharge end of the fan. The stock may be introduced into the pipe by means of a hopper having at its bottom a vane or nozzle projecting into the conveyor pipe at such an angle as to cause an injector-like action at the point of

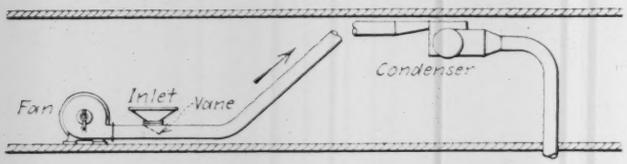


Fig. 10 Arrangement of Injector Inlet for Pressure System

inlet (see Fig. 10). This device is practicable, however, only for distances up to about 75 ft. Another method adapted for longer distances is to use a pair of flexible surfaced rolls forming the upper part of an air-tight feed box (see Fig. 11).

(*b*) *Vents.* At the delivery end, with either of the above arrangements, the pipe should terminate in a bin, with tight walls, with vent through a screen piped to such a point that no blast of free air can enter any important room.

MECHANICAL CONVEYORS

As with the best of machinery and with all the safeguards thus far described, all fires cannot be eliminated from the picker room, it is important that the extent of such fires as may still occur be made as small as possible. This is especially desirable in mills which

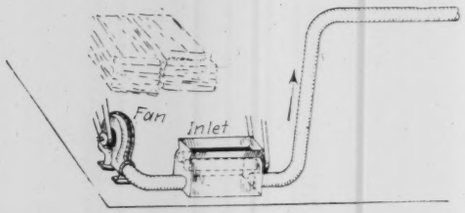


Fig. 11 Arrangement of Feed Box Inlet for Pressure System

store temporarily in bins in the room considerable quantities of opened cotton of various long staples.

Mechanical conveyors are often used between the opening room and picker room bins. In such cases these rooms are usually near each other. The older method of passing these conveyors through openings in partitions between adjoining bins has proved objectionable, as fire may enter several bins at the same time. To avoid this objection the conveyor can be placed over the tops of the bins, discharging through protected traps in the top. This arrangement requires considerable head room.

Another arrangement is to place the conveyor high up at the front or rear wall of the bin and discharge it through small protected openings in the wall. This can best be done where the bins are not deep from front to back, and where the conveyor has discharge from its side (see Fig. 12). In either case the openings for feeding bins from mechanical conveyors should be protected by tin covered shutters interlocking with the switch of the conveyor so each shutter will be open only when its bin is being filled.

SPRINKLERS

Having limited the number and extent of fires, the matter of controlling promptly those which do occur, should be cared for. In addition to the automatic sprinkler equipment always needed at the ceil-

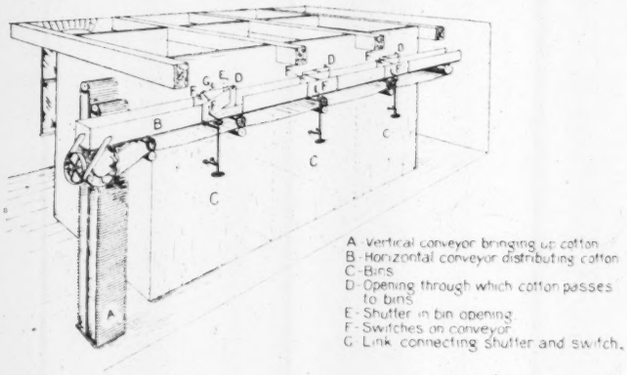


Fig. 12 Mechanical Conveyor so Located as to Discharge through Protected Openings near Top of Bins

ing of the cotton working rooms, sprinklers should be placed in the bins, in the condensers, under traveling aprons, inside and under picker trunks and close over the cotton in the hoppers of the automatic feeders.

DISCUSSION

Albert W. Thompson. Referring to the objection of Mr. Burnham to the using of relay fans, through which the cotton can pass directly, in cases of extreme length, in place of making substantially two systems, that the cotton in passing through the fan is likely to strike a fire due to the clogging, possibly from a poorly installed fan, from hot-bearings at the fan, or foreign substance passing through, if they get by the first point where they are supposed to drop out, do I understand this statement is based on actual experience? I have seen one or two systems of considerable length arranged in that way, and I do not recall now ever having seen a fire traceable directly to the fan. Most fires have originated in some other place, either in the opening room, where a device something like a picker is sometimes used for tearing bleached or dyed cotton, and where matches sometimes start fires; or at the finisher picker room at the other end of the system; but I do not

recall having seen a fire, directly traceable to the use of a relay fan.

C. J. H. Woodbury. I believe this paper is the first of its type which has been presented before any of the technical societies. That these occurrences in and of themselves are not preventable in any given instance appears to be conceded by Mr. Burnham, who correctly represents the practical experience in the matter. Many years ago, phosphor-bronze picker blades were introduced because they would not strike fire, or so it was stated; but whether that allegation was proved in practical experience beyond a diminution of such fires, is extremely doubtful. There is one class of distribution of such fires where it has been prevented, and that is the fires caused by striking in the picker and spreading down into the dust-room below, and then backing up through the dust flue into another picker which was not then in use. That has been prevented by unbalanced dampers at the end of the dust flues, so that when a picker was not in use, those dampers would naturally close and prevent that. I would like to ask the speaker if the principle of the automatic link, which has been applied so successfully to fire doors has not also been applied to dampers in these flues, so that whenever a fire occurs a flue would be closed at a very early stage in the story?

The illustrations represent the method of feeding the opener or bale breaker directly over open bales of cotton; whereas in many mills they put an ageing pile for the purpose of letting the cotton receive the air, and also get the effect of time in resuming its spirility, and its contact with other fibers, which it has lost by the compression it has undergone in the bale. There are various types of these ageing stacks in the English mills. They use them for the purpose of blending the various grades of cotton, or of mixing with the cotton the card waste, to the extent of making a new art almost in the blending of cotton for specific purposes, of which the American cotton manufacturers, I regret to say, know practically nothing. The cotton is put in strata in the pile from the various types of cotton, the Egyptian cotton, the American upland, and not forgetting as large a portion of card waste as the fabric will stand. Then they rake down the cotton along the end of the pile after it has remained there a week or so, with a large wooden garden rake, and a blending is effected in that manner. Another question is: Whether the exhaust blower is as efficient in moving cotton through rarefication of the air as a pressure blower would be?

John A. Stevens asked what data he has on fires caused by matches, referring to the paper in which he mentions fires started by matches; also where the large number of matches came from.

E. V. French. Mr. Woodbury has touched upon the matter of aging cotton. Where aging is done large mills may open 50 or 100 bales of cotton at a time. If a fire occurs under such conditions it is almost sure to run over the whole pile in spite of any extinguishing apparatus and cause a good deal of loss. Many mills on coarse work have found where the cotton is handled by blowing, that the passage through the pipes in loose form, and with an ample air supply, accomplishes about the same result as the ordinary aging. Only 10 or 12 bales therefore need be opened at once and the cotton from these is carried directly to the automatic feeder at the inlet of the blowing system. This gets rid of large amounts of loose open cotton, and makes a distinct gain in the reduction of the fire hazard. Picker rooms are causing a large number of our cotton mill losses and improvement at this point is the next thing to take up. If we can eliminate a good many of these fires the cotton mill will become about as safe as the average risk. In the question of matches which Mr. Stevens mentions, I remember one case where arrangements were made through a public officer to search the men in a cotton mill; the result was two handfuls of matches found in their pockets. As they work a match will now and then drop from their clothes to the floor, to be stepped upon or run over by a truck, and strike fire which will surely ignite anything combustible nearby. This is undoubtedly one of the most serious causes of fires in such mills today.

Charles H. Bigelow. In answer to Mr. Stevens, said that in the South he had seen the negro workmen handling matches and seen a number of fires caused by dropping the matches which were cracked by the trucks passing over them and set fire to the cotton, sometimes catching into the cotton on the truck.

The Author. In reply to the questions of Mr. Thompson, I know of one system where two fires occurred. It was a particularly long system, the fires blowing through the outlet side of the system, but no trace of fire had been found on the suction side of the fan.

Replying to Mr. Woodbury, in regard to stopping fires passing through the dust flues from the pickers by means of the fusible link, I do not think that method is extensively applied. I have heard of places where they tried to apply that method to cotton passing through pipes but I think the fire usually gets by the fusible link, as it takes a considerable length of time to melt the solder on the link. As to the unbalanced dampers, they are very efficient and I have no objection to urge against them. They are a great protection against fire backing up in the pipes.

The reference to the ageing qualities and the blower system, has suggested to my mind the fact that the quality of the cotton is improved by being blown through the pipes. I know of a number of cases where ageing bins have been put into mills for trial and then discarded as the passing of the cotton through the pipes was found to answer almost the same purpose. That may not be true of all cases, but it is in many. As regards the relative efficiencies of suction and blower fans, I have no data on that point; I think very few accurate measurements have been made to determine this.

Referring to the question of Mr. Stevens, the data are not exact, for as a rule in such cases the matches are destroyed. Some times we find the remains of the match, and often we find hard substances that have passed through. But many fires ascribed to matches are no doubt caused by matches, and we reach that conclusion from the fact that every other cause of fire we know anything of has been eliminated. That, perhaps, is not absolutely conclusive. The match fires, however, still remain the hardest ones to contend with or to trace to a cause.

In the South I think the laborers are largely responsible for many of the fires due to matches. The matches may be dropped by workmen around the gins, or even at earlier stages, before they get to the gins. It is a common practice among the negroes of the South to stick matches in buttonholes, in pockets, back of their ears, and in their hat-bands.

TEXTILE COST ACCOUNTING: ITS PURPOSE AND APPLICATION

By C. B. Annett,[1] New York

and

C. F. Cunningham,[1] New York

Non-Members

Cost accounting, as the name implies, is the application of the science of accounting to the determination of costs. Its fundamental principles are applicable to all lines of industry. It is really only a detail of the large question of organization, and it is therefore evident that this detail cannot be solved independently. There must be:

a "A clear definition of the departments of the business so that similar work and similar functions shall be grouped in one department.

b "A positive definition of duties of each department and its relation to the general business.

c "A clear fixing of the responsibility and a willingness to have responsibility rest with the heads of the various departments.

d "Scrupulous care to communicate the various wishes of the Chief Executive through the proper channels, that the responsibilities fixed may be preserved and each department limited to its particular functions.

e "The harmonizing of the commercial accounts, that is, the representative accounts of the business with the general scheme which is to be followed in the factory accounting or cost-keeping department. . . .

f "A proper head to the department of cost-keeping who must be as much an engineer as an accountant, and capable not merely of compiling figures, but of using the information when the facts are compiled; for the end of cost-keeping is cost reduction. This man must be so efficient that he may be depended upon by the highest official of the company and he will naturally be high in the counsels of the latter. . . . A man who fills such a position will have no sinecure."[2]

It is perfectly obvious that costs which are inaccurate, are not worthy of consideration and in fact are worse than none at all, as they are often entirely misleading. It therefore seems desirable before entering upon a discussion of specific methods of obtaining costs, to discuss briefly the fundamentals essential to all cost accounting.

The first essential is that cost should be a statement of fact, all assumptions, in so far as possible, being eliminated. In contradistinction, an estimate, or estimated cost, may not agree with the real cost because of the very fact that it takes into consideration probable changes of conditions.

The lack of a clear understanding of the difference between a cost and an estimate, has frequently led to much confusion and the distinction between the two cannot be too clearly defined. Many manufacturers seem to fall into the habit of allowing themselves to believe that cost is what they wish it to be, rather than a statement of the real facts, and this almost invariably leads to disaster.

To make this important point clearer, consider that an order for a fabric has been received, conditioned on a certain price. The records show that this fabric was previously made at a certain cost. It obviously would not do to accept the order without taking into consideration all changes in conditions that have taken place since the former production. Wages may have increased, automatic looms may have replaced plain looms, the price of raw material may have advanced, and a number of the elements of cost may have changed, which would alter the previous cost. Consequently an estimate is made, based on the known facts taking these changes into consideration as accurately as possible. The order is accepted because the estimate indicates that, provided the conditions considered therein hold true, a profit should result from the sale. During the actual manufacture of the order, however, alterations of conditions occur which were not anticipated in the estimate. The production decreased, the shrinkage increased, the percentage of second quality good increased; perhaps a number of such cost factors varied. In consequence the anticipated profit becomes doubtful and it is, therefore, evident that the estimate cannot be used as a guarantee of profit. After the fabric is completed, the cost is carefully compiled and the true cost, regardless of the existing conditions, determined. This affords a proof of the accuracy or inaccuracy of the preliminary estimate, determines whether or not the order has been profitable and becomes a basis for estimating more accurately on future orders.

The second essential is predicated upon the first, that if cost is to be a statement of fact, it must be subject to proof. In order to insure this, it is essential that the person responsible for its compilation have full access to the most private information of the company's affairs and the unqualified confidence of its officers in order that every item of expense be included. Further, the accounting methods should be so arranged that the results obtained are carried to, and incorporated in, the commercial (private) books of the company.

[1] Gunn, Richards & Co.

[2] James Newton Gunn, "Engineering Magazine," January 1901

Presented at the Annual Meeting, New York, 1913, of The American Society of Mechanical Engineers

The third essential is that the several departments involved work in complete harmony. All persons having to do with the recording and tabulating of statistics must work together for the single purpose of reporting information not alone accurately, but also promptly, in order that the data so recorded may be available before they become history. The sources of much of the information essential to cost must, of necessity, be from persons in the mill who are of a grade of labor lower than that responsible for the compilation of the costs, and, it is especially necessary, therefore, that they be impressed with the importance of the information they are recording.

The control of all materials not in process should be under the direction of a general storekeeper, and the control of production under a production manager.

It should be the function of the production manager to control production from the raw material to the finished product. Changes in production methods should be made only through the production manager and it should be his duty to at all times keep the cost department fully informed as to the methods in force and the quantities produced.

The general storekeeper should have charge of and be responsible for all raw material, semi-finished and finished stock wherever located. This does not necessarily imply that all stores should be centralized in one place, but it does imply that one person should be held responsible for their proper care and for correct reporting of the receipts and disbursements of all materials.

Manufacturers sometimes argue that because their material is not liable to depletion by theft, from the lack of its value to an individual, they may safely figure their costs on the basis of a theoretical schedule of the material that should enter into any given unit of their product. Similarly, all indirect materials purchased are sometimes charged directly to expense and all direct materials to product, but this procedure is apt to prove embarrassing at times, as there will be an inventory of material on hand which theoretically has no value because it has already been charged to product. Moreover, this practice is not conducive to accuracy as purchases of material are not necessarily made according to the manufacturing need for this material. It is usually found that savings may be made by buying in quantities sufficient for several months' normal operation of the mill.

Total cost may be divided into three main parts or divisions: (*a*) manufacturing or mill cost; (*b*) selling cost; (*c*) administrative cost. The latter two are generally known as commercial expense and are distinct from manufacturing or mill cost. They are usually combined and added to the manufacturing cost on a single percentage basis. While this is reasonably correct in a great many cases, it should be avoided wherever it is possible to obtain a more equitable basis. Many manufacturers dispose of their product through a selling agency or commission house, and therefore know exactly the selling expense chargeable to each fabric and should accordingly, apply this selling expense directly to the product.

Manufacturing cost is the sum of the following: (*a*) direct material cost; (*b*) direct labor cost; (*c*) indirect cost or burden.

Direct material cost includes the cost of all material entering into the product and directly assignable to it, and direct labor cost the wages paid which are directly chargeable to the product.

Indirect cost or burden includes the cost of labor and material and miscellaneous expenses not directly chargeable to the product, such as superintendence, power, heat, light, depreciation, etc. Speaking generally it includes all items not included in direct labor or materials.

Each of the above may be subdivided, if desired. The indirect cost, particularly, is a complex item and can be treated more readily if segregated, for instance, into (1) power, heat and light; (2) departmental expenses; (3) general expense.

The cost of power, heat and light includes all expenditures incident to the production and distribution of power, heat or light. It is desirable to distribute the cost of power, heat and light by actual consumption. Obviously more power is required to operate a heavy 72-in. loom than a light 28-in. one. A department using steam for manufacturing and heating should be charged proportionately more for steam than a department using it only for heating. The proper percentage may be obtained by actual measurement or it may be approximated from tests. While the former method is preferable, the latter is sufficiently exact if proper facilities are had for making accurate tests.

Departmental expense includes all items of expense which can be charged directly to a department, for instance, departmental supplies, foreman's wages, fixers' wages, etc. It can be apportioned to the product by one of a number of methods.

General expense includes all items of expense which are not directly chargeable to a department, and which therefore must be apportioned to the departments on a more or less arbitrary basis.

There are two general methods of collecting cost data: (*a*) by definite lots or orders; and (*b*) by operations. As the name implies, the first method provides for the determination of the cost of definite quantities of product and is applicable only to cases where the material can be processed in definite lots and kept intact through the several operations. These requirements render this method impracticable in such textile mills as largely manufacture what are known as staple products. The production in such cases is so continuous that it cannot be readily segregated into lots or batches. The plan is therefore applicable only to what are known as specialty or fancy mills in which

it is the general practice to process the material in lots of comparatively limited quantities.

In order to insure that all expenditures incurred are included in the cost, it is necessary that all labor performed and material consumed should be charged to some form of order: Production orders for all labor and material expended on product intended for sale, plant orders for all expenditures for plant improvement and extension, and standing orders for all expenditures that cannot be charged directly to either production or plant orders.

Production orders should be issued as the authority for processing all materials entering directly into the product. They should be numbered serially and all expenditures of labor and material on account of same should be charged to these numbers. It should be noted that it is not essential that an order should cover the complete process from raw material to finished product, but it is necessary that it should cover a complete stage of production.

Plant orders, like production orders, should be numbered serially and should serve the purpose of collecting the various items of labor and material expended on plant improvements and extensions.

Standing orders should be issued for collecting all expenditures of labor and material necessary for the efficient operation of the mill except those chargeable to production and plant orders and they will, therefore, embrace all indirect cost items. By means of standing orders, a minute and careful periodical comparison may be had of all manufacturing, administrative and selling expenses.

All disbursements of materials from stores should be priced at cost and charged to the proper order number. This will not only insure that all expenditures of material are accounted for, but it will also provide a means of collecting individually the material cost of the several orders.

There are several methods in use for collecting labor cost data. It has been in the past quite generally the practice to allow the workman to make his own record, or have his foreman or overseer do it for him. A better plan is to place the responsibility upon timekeepers, whose sole duty it is to collect labor information. Timekeepers should be supplemented, so far as possible, with mechanical recorders which can neither err nor misrepresent.

After obtaining the direct material and labor cost, the next step in the tabulation cost is to apply the indirect cost or burden. We shall not attempt to discuss at length the various methods of distributing indirect cost. The problem is much simplified if the departments are so defined that only similar operations and processes are contained within a single department. Distribution of expenses may be divided into two parts: first the distribution of the general expense of the mill as referred to above, together with power, heat and light to the producing departments; and second, the apportionment of the total departmental expense thus obtained over the product passing through the departments.

The first is not, in reality, extremely difficult, but it does require a certain amount of patience and study to determine the most equitable method of distributing the several items making up this general expense. Power, for example, as mentioned previously, should be distributed on the basis of power consumed, depreciation on the basis of the value of the plant and equipment used by the department. In a similar manner each item of general expense should be taken up, and the most equitable method of distribution determined.

The total departmental indirect cost thus obtained may be apportioned over the product by any one of several methods. It is quite generally desirable in textile mills, however, to use the machine hour basis or its equivalent, as the machine is largely the unit of production.

It will be readily seen that the cost of direct material and direct labor can be determined as soon as the order is completed, but that the exact amount to be added for indirect expense cannot be ascertained until after the close of the period.

It is, therefore, common practice in figuring current costs, to use the rates based on the results of previous periods. While this is the only practicable method to pursue when immediate cost figures are required, it nevertheless, is liable to error and should only be used when it is not practicable to wait until the close of the period.

The second method, that of operation costs, as the name implies, provides for the determination of the cost of individual operations. It is self-evident that, given the total cost of each operation and the loss by shrinkage of material from operation to operation, the total cost of any product, or the cost at any desired stage of completion may be found by combining these costs in the proper manner. They must, however, be combined only with a full knowledge of the shrinkage and the exact order in which the several operations were performed. This method is applicable to mills in which production is continuous, and, therefore, is adapted to a large class of textile mills, especially those manufacturing staple cotton goods.

The foundation of operation costs rests upon an accurate knowledge of the production of each operation, or, stated another way, of the shrinkage from operation to operation. There are in use several methods of measuring production, but none of them are entirely satisfactory.

Because of the well-known fact that the majority of the fibres used in the manufacture of textiles are subject to a considerable variation in weight, due to the rapidity with which they absorb and discharge moisture, if weight is used as the unit of measure it is subject to a corresponding variation. While lineal measure would solve this difficulty it would so com-

plicate the recording of the quantities of stock in process as to make the plan impracticable. Everything considered, the most practicable unit of measure for yarn, both finished and semi-finished, seems to be the pound. Cloth may be measured either by the pound or the yard, whichever is the more convenient.

As it is impracticable to actually weigh the product after each operation it is necessary to resort to some mechanical method of measurement. The most common method is the use of measuring clocks. Clocks are subject to possible error in that they measure the production based upon a fixed standard of efficiency, while it is, of course, self-evident that any individual machine will fluctuate in its efficiency due to a number of causes.

The collection of the cost data under this plan differs from that used in the first plan, in that there is no special production order number against which the various expenditures of labor and material can be charged and it is, therefore, necessary to use the operation as the unit of cost. It is essential to this scheme that the various operations be definitely determined and designated by a number. The several different kinds of product should also be numbered. A special ledger for collecting the cost data should be furnished in which provision should be made for collecting the direct material costs separately from the direct labor and the indirect cost.

All disbursements of direct material from stores should be priced at cost and charged in the mill ledger to the first operation through which the material passes, classified to kind of raw material. Provision should be made for crediting the several raw material accounts with the value of the waste made in each operation. The direct material accounts should be subdivided as to kind of raw material, rather than kind of product, as it is usually impracticable to obtain a report of waste classified as to kind of product. At best, the obtaining of accurate reports of waste made is a difficult proposition, especially in a mill where several kinds or grades of raw material are being processed along the same general lines, and quite possibly in the same rooms. It is important that this information be obtained as accurately as possible, in order that each operation and each kind of material may be credited with the proper amount for waste. The customary practice has been to consider that the shrinkage is the same for all kinds and grades of raw material and product. Shrinkages, on the contrary, are constant only in so far as the cause is either natural or due to mechanical appliances, and shrinkages due to "human elements" are subject to wide variation. Considering that the waste in woolen mills is over 50 per cent of the raw material and in cotton mills over 15 per cent, it seems well worth while to give this problem serious consideration. A mill agent once pointed to his waste wagon and aptly remarked, "there go our dividends." Apparently in many cases dividends might be increased if more attention were given to the reduction and utilization of waste.

All direct labor should be analyzed as to operation and kind of product and charged in the mill ledger to the proper account. The total indirect cost for each operation should be determined in much the same manner as explained under lot costs. It should then be apportioned to the several kinds of product and charged to the proper accounts in the mill ledger. At the close of any period, the unit cost of any operation may be determined by dividing the total expenditure on the operation for the period, as shown by the mill ledger, by the total amount of product which has passed through the operation during the same period.

The total cost of any given product cannot be determined simply by adding together the several operation costs, considering the shrinkage from operation to operation. To obtain the cost of any operation in the completed product, it is necessary to increase the operation cost, in reciprocal proportion to the shrinkage from the end of that operation to the finished product. For example, if the cost of an operation is \$0.015 and the shrinkage of product is 25 per cent, the operation cost in completed product would be $\frac{\$0.015}{100\% - 25\%} =$ \$0.02. It would be possible to determine the total cost of product by this method, except for the fact that the exact sequence of operations is not readily ascertainable, making it impossible to determine accurately the amount of shrinkage, especially in a mill making a variety of products.

A more satisfactory method is to build up the total cost, operation by operation, beginning with the first operation and charging forward to each succeeding operation the cumulative cost of all preceding operations, inventories of course considered. This plan has the advantage, in that it follows the product from operation to operation, according to the manufacturing layout and schedule.

It is obvious that the output of an operation plus the waste made is equal to its input. Providing no inventory exists between this and the succeeding operation, the good output of the first operation is equal to the output of the second, including the waste made. Ordinarily, however, inventories do exist and must, therefore, be taken into consideration. An equation taking inventory into consideration may be made up as follows: The good output of the first operation, plus the inventory of the product of that operation at the beginning of the period, less the inventory of that operation at the end of the period, is equal to the input of the succeeding operation. If it were practicable to determine the input of each operation, it would be possible by means of this formula to determine the inventory on hand between operations, at the end of any period; but in most instances there seems to be no practical method of obtaining the input of each operation. Consequently, a physical inventory

of the product in process must be taken whenever the inventory is desired. With the inventory a known factor, by means of the above equation the quantity and value of the product to be charged forward from operation to operation can be easily determined. Each successive operation should be charged with the total cost of all preceding operations, inventories considered, and by this means it thus becomes possible to determine the accumulated cost of any product at any stage of completion.

The accumulated unit cost may be obtained by dividing the accumulated cost at that stage of production by the output of the operation. This unit cost should be used in pricing the physical inventory of the product from that operation.

In many cases, the product of one operation is made into a number of different kinds of product in a succeeding operation. For example, one size of roving may be spun into several sizes of yarn and it is necessary in such cases to apportion the amount charged forward from the previous operation to the succeeding operation, based on the total production of each kind of product in the succeeding operation. It will be evident that by this method of cost finding, the inventory of product in process is automatically priced and, further, that it is possible to determine the cost of the product shipped during the period. The operation cost method not only provides for obtaining the detail costs by operations, but also the total cost of each kind of product.

Cost accounting is most valuable from the standpoint of the manufacturer, in that it shows numerous ways for reducing operating costs. It is self-evident that accurate costs are of fundamental importance as a guide in determining whether to meet or withdraw from unintelligent competition. They are also essential in the preparation of financial statements, as a knowledge of costs is absolutely necessary to the proper valuation of assets, and for the making up of a profit and loss account.

As heretofore mentioned, a mill or inventory ledger should be opened, designed to collect and control the various facts regarding the manufacturing costs and inventory records. This should be done regardless of whether costs are determined by means of the definite lot or operation plan. The mill ledger should be controlled by the private ledger and at the close of each period should be in balance with the controlling account in the private ledger.

The various items of expense not distributed or applying to product in process, should be so segregated that they can be easily checked against uncompleted costs and the uncompleted costs in turn checked against the product in process account. By this means at the close of each period, be it one or four weeks, or one of the calendar months or several months, the accuracy of the costs compiled during the period is demonstrated.

SPECIFICATIONS FOR FACTORY TIMBERS

By F. J. Hoxie, Phenix, R. I.

Member of the Society

This paper is given in the hope that a discussion may be opened which will bring together scattered experiences relative to the properties underlying the qualities required in mill timber. Within three years more than $100,000 has been required to repair damage due to dry rot in mills insured by the Associated Factory Mutual Fire Insurance Companies, and nearly all of the lumber affected was hard pine in comparatively new buildings. This rapidly increasing destruction of lumber is unquestionably due to the use of poorer material than was employed in former years. In a lot of large timber for the frame of a new mill will be found nowadays scarcely anything but North Carolina, Cuban, or Shortleaf pine. The best qualities of these varieties are probably as resistant to decay as is the Longleaf pine, but they are less uniform; the poor qualities are much more difficult to detect because of the necessarily superficial acceptance inspection of the purchaser or his representative.

In textile mills the high artificial atmospheric humidity undoubtedly increases the tendency to rot in pine of low natural resistance to fungus. The weaving rooms of cotton mills are frequently maintained at a saturation of moisture of 70 to 80 per cent. With 70 per cent saturation and a temperature of 80 deg. fahr. a decrease in temperature of 12 deg. or more would cause precipitation. This condition can be found in winter on the under side of roofs or at beam wall bearings or windows if the heat insulation is not very complete.

Dry rot fungus will grow on the surface of wood at atmospheric saturation from 96 to 100 per cent[1]; it will grow inside of large beams of susceptible material at a much lower atmospheric saturation. In one case investigated, the room was maintained at 60 per cent and the beams of the second floor which were not exposed to outside temperatures were attacked. Experiments tending to show that the dry rot fungus is able to form sufficient water for its requirements in beams of large size by decomposition of the wood are given by Mez[2]. Wet spots frequently remain several days on the freshly sawed surfaces of beam sections containing living fungus (see Fig. 3). There is no question whatever about its growing inside of factory beams of non-resistant material for two or three years at least after the factory is built, with less than 70 per cent of atmospheric moisture and in rooms where water

[1] Hausschwammforschungen, vol. 6, p. 308; Moeller, Jena, 1912.

[2] Der Hausschwamm, Carl Mez; Dresden, 1908, p. 192.

Presented at the Annual Meeting, New York, 1913, of The American Society of Mechanical Engineers.

is not used in manufacturing processes. This condition has been found in several of the worst cases investigated.

Only hard pine timber will be considered here as this is the most generally used material for heavy mill frames. Spruce is sometimes used for floor plank, but this is probably more susceptible to rot than the better qualities of hard pine. In the only case investigated where spruce was concerned the disease evidently spread from pine beams to the spruce floor planking.

Echinata), Cuban (*Pinus Heterophyila*), and North Carolina (*Pinus Taeda*). They are very fully described in Timber Pines of the Southern States, by Charles Mohr.[2] The Longleaf pine is the most valuable for lumber from its greater strength and durability. The latter quality is probably due chiefly to the high percentage and uniform distribution of the resin and to the small percentage of sap wood, which averages not over 2 in. in radius of mature trees, while that of the other three varieties varies from 4 in. to 6 in. of the radius.

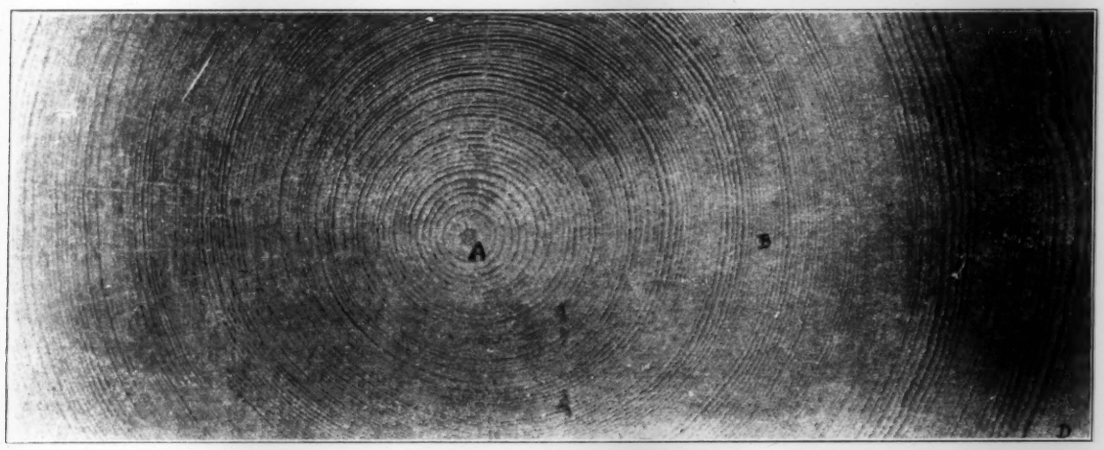


Fig. 1 Longleaf Pine, 8 in. by 18 in. Distribution of Resin: *A* 25 Per Cent, *B* 14 Per Cent, *C* 17 Per Cent, *D* (Sapwood) 3 Per Cent

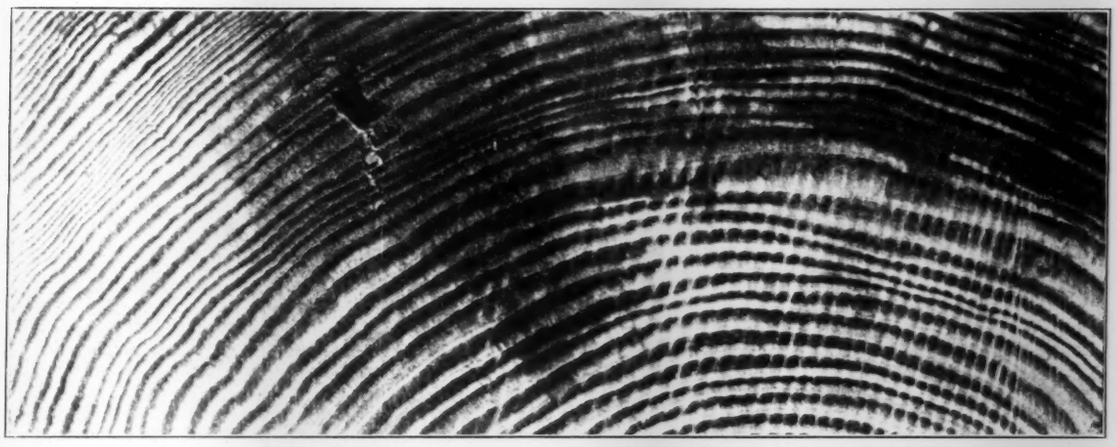


Fig. 2 Cuban Pine, 8 in. by 18 in. with Rot in Sapwood

In a few cases hemlock without antiseptic treatment used under floors in basements has failed in a few years. Hemlock, oak and white pine have failed after longer or shorter service, but the use of these materials for mill construction is not sufficiently frequent to require more than passing mention.

Twenty-six varieties of hard pine, growing in North America, are described by Penhallow;[1] of these only four are much used for timber in the eastern states, the Longleaf (*Pinus Palustris*), Shortleaf (*Pinus*

Many of the specifications for hard pine are vague or meaningless owing to the fact that the terms used are not clearly defined or are not determinable. For example "best quality" could honestly be taken to mean either the best in the local market or the best in the world. "Longleaf pine" is practically impossible to identify beyond a doubt in the form of lumber, and in fact it is now rather the exception than the rule to find this variety of pine in the large sizes required for mill beams. Other varieties are regularly accepted

[1] A Manual of the North American Gymnosperms, D. P. Penhallow, 1907.

[2] Bulletin No. 13, U. S. Department of Agriculture, Division of Forestry, 1897.

as Longleaf. "Georgia" is sometimes added to a specification but lumber grown in that state is seldom insisted upon, nor is its place of growth important.

The interstate rules for Yellow pine lumber for 1905 define prime quality, dimension sizes, as follows:

All square lumber shall show two-thirds heart on two sides, and not less than one-half heart on two other sides. Other sizes shall show two-thirds heart on face and show heart two-thirds of length on edges, excepting when the width exceeds the thickness by 3 in. or over, then it shall show heart on the edge for one-half the length.

the deep, narrow sections frequently used for double beams.

The average number of annual growth rings per inch has been suggested as a criterion for selecting good hard pine lumber, as follows:[1] first quality should have 15 or more rings per inch, as an average of 5 in. across the grain; second quality should have an average of from 8 to 15 growth rings, and material having less than 8 should be considered unfit for structural use. This would admit such material as that shown in Fig. 4 and exclude such as that shown in Fig.

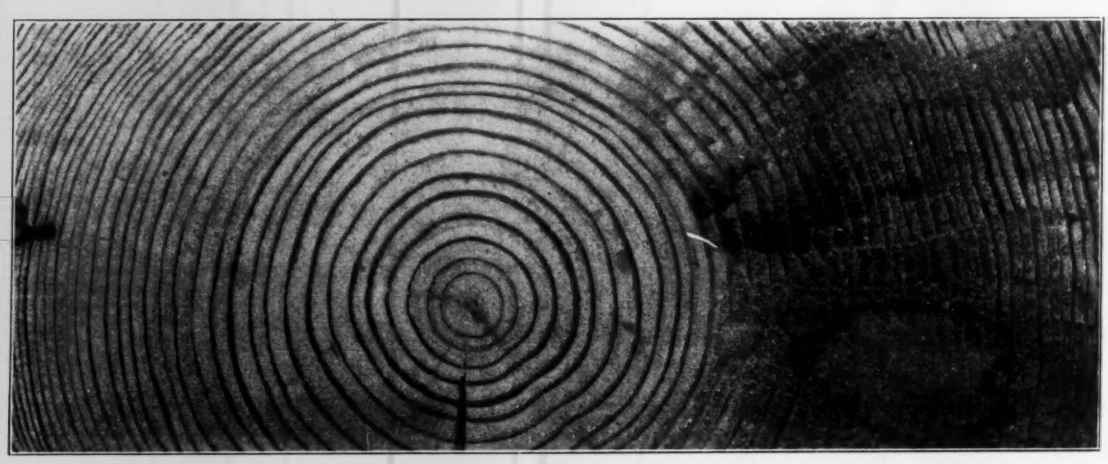


Fig. 3 North Carolina, or Loblolly, Pine, 8 in. by 18 in. with Rot in Nonresinous Wood

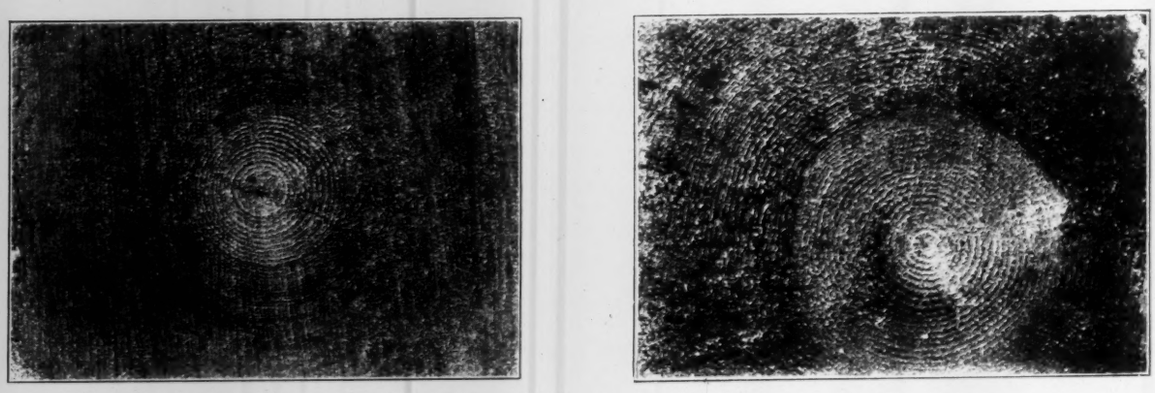


Fig. 4 Sound and Rotted Sections of 12 in. by 14 in. Beams; Probably Shortleaf Pine

The rules define merchantable inspection as follows:

All sizes under 9 in. shall show some heart the entire length on one side. Sizes 9 in. and over shall show some heart the entire length on two opposite sides, etc.

This specification for prime quality loses most of its force when applied to pine of the type shown in Fig. 4. The young heart wood has rotted nearly, or quite as rapidly, as the sapwood. Most of the beams shown in Fig. 6 are of this variety. Timber of merchantable inspection, in addition to the uncertainty of the heart wood mentioned above, has the practical certainty of rot in the sapwood if conditions are not most favorable. This grading is particularly treacherous with

5. The dense coarse grained resinous Cuban heart wood is as strong and durable as the Longleaf pine, its bad quality being that it has a large percentage of not very clearly marked sapwood which is rapidly destroyed by fungus (see Fig. 2).

A later suggestion which has been adopted by the American Society for Testing Materials[2] calls all good material Longleaf pine and poor material Shortleaf pine. This is unfortunate in that an arbitrary mean-

[1] American Society for Testing Materials, Proceedings 1909 p. 291.

[2] American Society for Testing Materials, Proceedings 19 p. 345.

FIG. 5 BEAM 8 IN. BY 12 IN., WEIGHING 72 LB. PER CU. FT.

ing is given to the names Longleaf and Shortleaf, which already have a generally accepted botanical meaning; such a discrimination is also incomplete in not defining the qualities of the two classes.

The positive identification of Longleaf pine lumber is difficult or impossible. There are slight microscopic differences in the form of the medullary rays of the North Carolina pine, as given by Penhallow[1] and Roth,[2] but to use them for identification would require considerable experience in the microscopic study of the pines. The macroscopic differences are more striking with characteristic specimens. The Longleaf pine is heavy, resinous and fine grained, averaging for the dry heart wood from the butt of the tree, according to Sargent[3] 43.7 lb. per cu. ft. (see Fig. 1). The Cuban pine is slightly heavier, averaging 47 lb. per cu. ft., resinous and coarse grained with a large proportion of dense summer wood and a much larger proportion of sapwood (see Figs. 2 and 5). The North Carolina pine is lighter, averaging 34 lb. per cu. ft., somewhat less resinous, coarse grained with a small percentage of summer wood (see Fig. 3). The Shortleaf pine is moderately light, averaging 38 lb. per cu. ft., the least resinous of the four and of medium coarse grain. The following are the weights per cubic foot given by Mohr for kiln dried material; Longleaf 36 lb., Cuban 37 lb., Shortleaf 30 lb., and North Carolina 31 lb. The reason for Mohr's weights being less than those of Sargent is that he takes the average of the tree, the top of which is much lighter, while Sargent considers only the denser heart wood at the butt. There is consider-

[1] North American Gymnosperms, D. P. Penhallow, 1907.

[2] Bulletin No. 13, U. S. Division of Forestry, 1897, p. 143.

[3] Silva of North America, C. S. Sargent, 1897.

FIG. 6 ROTTED 12 IN. BY 16 IN. PINE BEAMS REMOVED AFTER TWO YEARS' SERVICE

RESIN, PER CENT

A	B	C	A	B	C	A	B	C	A	B	C
7.72	5.12	0.83	8.36	4.89	1.17	4.46	1.99	0.76	5.36	7.04	0.68
9.45	2.31	0.82	3.45	18.81	0.99	6.26	6.56	0.58	29.21	12.17	0.88

able confusion in local names: Mohr gives six Latin and 29 common names as having been used at different times or different places for the Longleaf pine; the other varieties have nearly as many. The Cuban and Longleaf pines are sometimes confused since both have long leaves, while the Shortleaf and the North Carolina have short leaves.

A treacherous type of hard pine is shown in Fig. 4, which is probably Shortleaf pine, although it may be Longleaf grown under unfavorable conditions. The percentage of resin and the gravity is somewhat higher than that given by Mohr[1] for Shortleaf, but the arrangement of growth rings corresponds with his description. Hardly a lot of lumber is to be found of which this does not form a considerable proportion. Most of the rotted beams shown in Fig. 7 are of this type. It is characterized by a coarse grain at the center, generally consisting of four to six growth rings per inch, becoming regularly finer with increased diameter until at 6 in. or 8 in. from the center there are 20 to 30 growth rings per inch. The resin and resistance to rot decrease with the rings. At the center there is generally in the neighborhood of 10 per cent of resin; at 4 or 5 in. from the center there is frequently less than 3 per cent. The line between the heart and sapwood is well marked, the heart being much darker than the sap, as with the Longleaf. This material is regularly sold as Longleaf.

Tannin in the lignified heart wood is said to retard fungus growths in oak,[2] but resin is the important factor in the hard pines. The following experiment was made to show the effect of resin: A block of Longleaf pine 2 in. on a side, containing 18 per cent of resin was sawed in two across the grain. Half of it was boiled in benzole and after the removal of the resin the benzole was driven off. Both pieces were cultivated in contact with wood containing living dry rot fungus. At the end of a year the specimens were dried and weighed. That from which the resin had been removed had lost 8 per cent in weight, the other only 2 per cent.

Cuban pine is the heaviest and frequently the most resinous of the timber varieties. Fig. 5 shows a section of a beam weighing 72 lb. per cu. ft. It can be seen

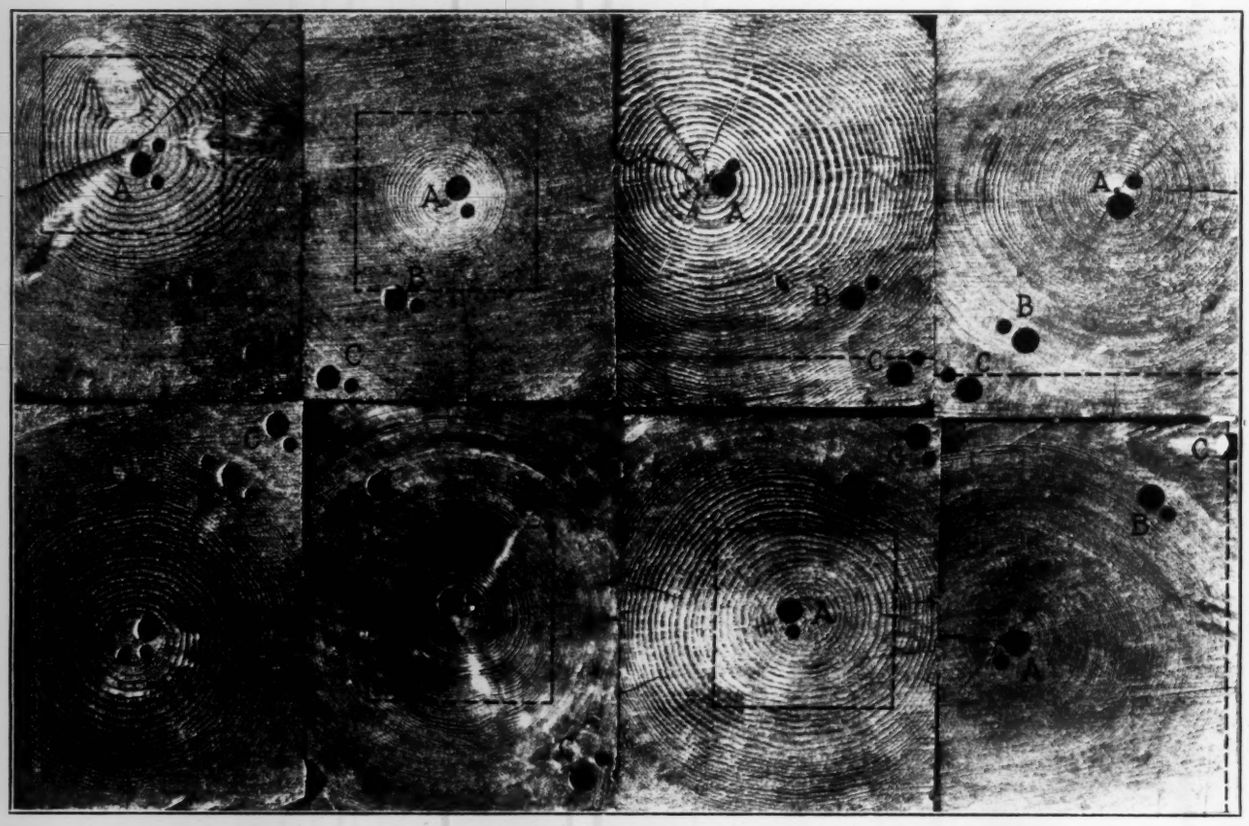


Fig. 7 New Selected 12 in. by 16 in. Beams

Resin, Per Cent											
A	*B*	*C*	*A*	*B*	*C*	*A*	*B*	*C*	*A*	*B*	*C*
14.6	2.7	1.6	12.2	2.4	2.9	34.7	14.1	2.6	13.1	14.1	2.6
12.3	3.0	2.4	8.6	3.2	0.8	12.3	3.0	2.4	7.5	11.3	1.1
Air Dry, Lb. per Cubic Feet											
37	42	37	36	39	37	46	57	61	40	44	34
34	36	30	37	42	33	39	45	36	42	55	50

[1] Bulletin No. 13, U. S. Division of Forestry, p. 13.

[2] Berichte der deutschen botanischen Gesellschaft, vol. 29, 1912, p. 704; Mycologisches Centralblatt, vol. 1, 1912, pp. 138 and 166

that besides being saturated with resin this is nearly all summer wood.

The ideal specification consists undoubtedly of a clear description of the qualities required. In structural timber these are strength and durability. With these qualities defined attributes, such as botanical variety, location of growth or grading, lose their importance. The limits of strength can be easily given, but less easily determined, without destroying the material. The density is probably a sufficiently close index of strength for commercial purposes and the percentage of resin of durability.

Both the resin and the density can be conveniently found by boring half-inch holes into the end of the beam, collecting the chips, drying and weighing them, extracting the resin with benzole and weighing it. Cuban or North Carolina pine with 10 per cent of resin is apparently as resistant to fungus as Longleaf pine with the same percentage of resin. Heart without resin is not a saving quality.

The percentage of resin in the sound centers of rotted beams taken from a mill was determined in order to get an idea of the amount required to stop fungus growth under ordinary mill conditions (see Fig. 7). In rotted beams of the poorest of hard pine there is generally a sound center which contains more resin than the remainder of the section. Sometimes it is not bounded by the growth rings but is very irregular, the cause being that resin has been irregularly deposited in the section owing to knots or injuries to the tree. The limits of the sound centers are frequently not the same as those of the heart wood.

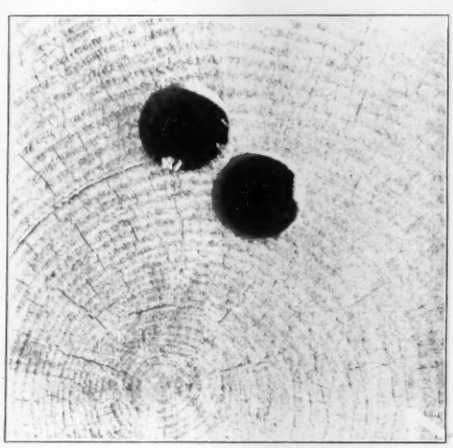


Fig. 8 Showing how Holes in Columns serve as Passageway for Fungus

It is apparent that the limiting amount of resin which is just sufficient to stop the fungus is in the neighborhood of 3 per cent. The limiting power of resin is undoubtedly not absolute but varies with the moisture, variety of fungus and time of exposure. Therefore, it is safe to assume that a mill beam should have not less than 5 per cent of resin throughout successfully to withstand fungus under ordinary conditions of dampness and allowing a reasonable factor of safety. Dye houses and paper mills would probably require more.

In order to determine the distribution of resin in timber of average good quality several sections from beams now being supplied for factory construction were analyzed. Part of these are shown in Fig. 7. The large holes were for samples for resin analysis, and the small ones for density determinations. The material was mostly heart wood and the price paid for it was $59 per 1000 ft. board measure. None of the sections have 5 per cent of resin throughout. Three would come within this limit by cutting off about 10 per cent and the remaining five would require a reduction of about 75 per cent, as shown by the dotted lines.

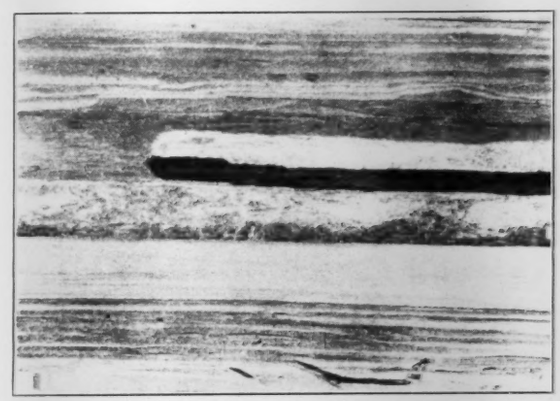


Fig. 9 Column shown in Fig. 8 split to show Fungus

If it could be logically assumed that better material could be bought by increasing the price in proportion to the reduction of the cross-section necessary to obtain the required 5 per cent of resin, $115 per 1000 ft. would be indicated. From such figures as I have been able to obtain this price is not far out of the way for such selected material in large sizes, and even at that price it is doubtful if a sufficient amount for a factory could be had in the required sizes. This indicates that hard pine with sufficient natural resistance to withstand fungus unassisted is out of the question at prices that compare favorably with other forms of construction.

Low power of resistance to fungus in the timber is frequently the last cause to which a serious dry rot outbreak is charged. Ventilation is generally the first preventative measure suggested. Dry wood which is kept dry is undoubtedly incapable of fungus infection but ventilation does not necessarily cause drying. Wood will become dryer or wetter in proportion to the relative humidity of the air; therefore, timber ventilated with moist air will have its rate of rotting accelerated if it is of a susceptible variety. Moreover the susceptible varieties absorb moisture more rapidly than those which are more resistant to fungus.

A heavy coat of paint may accelerate or retard the

rate of rotting, depending upon whether it prevents wood from absorbing or giving up moisture. The question of primary importance is whether the wood is resistant or susceptible to fungus.

Holes through columns and narrow openings between beams encourage fungus more frequently than they prevent it. One of the reasons given for bored columns and double beams has been that they prevent dry rot, and considerable importance has sometimes been given to this feature.[1] Undoubtedly columns with holes through them and thinner beams would dry out

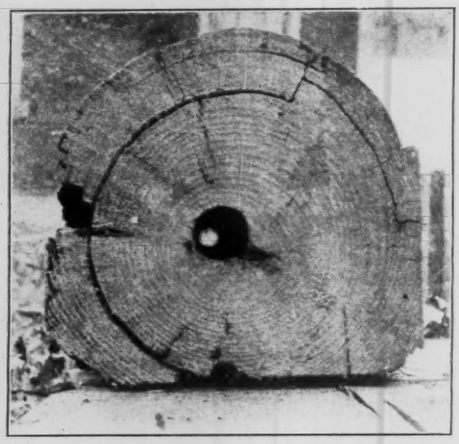


Fig. 10 Example of Bored Hard Pine Column badly rotted after Two Years

quicker, if given a chance to season, but the common custom of boring green or wet columns just before they are put in place in the building and using moist lumber for double beams leave ideal places for the growth of fungus, since the air in the openings is saturated with moisture. Holes in the columns are also objectional since they form a convenient passageway for the fungus to pass rapidly from floor to floor before the building has dried out. Fig. 9 shows a section of a bored pine column split in two with fungus growing through the hole; the column was not deeply attacked as can be seen from the photograph of the cross-section, Fig. 8. The hole is inefficient in preventing rot if the material of the column is susceptible, as can be seen from Fig. 10, which shows a section of a bored column badly rotted. Fig. 11 shows fungus growing in the opening between double beams, the front half of the beam having been removed.

In many old mills hard pine timbers are found to be sound after years of service in moist air. A careful examination will generally reveal the fact that these timbers are resinous Longleaf pine, practically no longer obtainable. There is no more reason for supposing that the nonresinous hard pines now in common use would prove as resistant than there is expecting moist hemlock or birch to resist fungus. There is still available for present requirements in mill construction sufficient hard pine of suitable size and strength. It remains to supplement its lower natural resistance with proper antiseptic treatment.

In conclusion, the following summary may be given:

a The percentage of resin in hard pine can be taken as an index of its power of resistance to rot, 3 to 5 per cent being the lower limit.

b Hard pine lumber 12 in. sq. or larger is not obtainable in quantities with sufficient natural resistance to withstand fungus in a moist location.

c Holes through columns, narrow spaces between beams and hollow spaces in floors or roofs are of little value in preventing rot, and often serve to spread it rapidly to all susceptible material.

d The only hard pine, which is now obtainable in suitable quantities, is not safe to use for the important parts of a mill without antiseptic treatment.

DISCUSSION

E. M. Bates. I would like to ask Mr. Hoxie how far the action of preservatives prevents this fungus growth inside of the beams? Does the treating of the pine timber with one of these preservatives until it is thoroughly saturated on the outside lead to conditions where dry rot can start on the inside? In other words, is the life of that timber dependent upon the wearing out of this water-proof surface on the outside? Also has he reached any conclusion as to the most effective method for treatment?

A. W. Thompson. I would like to ask what would be

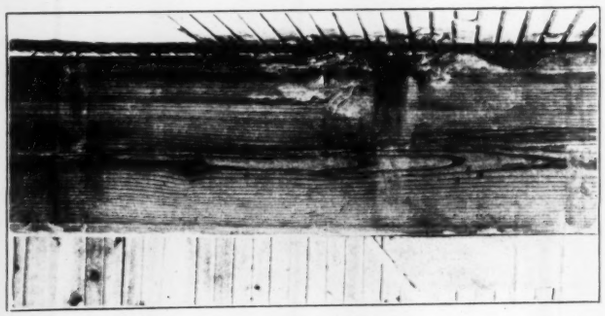


Fig. 11 View showing Fungus between Double Beams, Front Beam having been removed

the probable effect of carbolineum on material in an average mill, with the ordinary humidity, where artificial heat is used? Also what is the best practice as to painting timber? It has been the general impression that it is best to let them remain unpainted for a year or two after they are put into the mill.

A. M. Ernst. Must these preservatives be applied under a vacuum in order to secure their efficiency? Should timber put into the ground, such as fence posts, be coated wet, or is it absolutely necessary to have it dry to put on the preservatives?

Charles H. Bigelow. The author speaks of a number of mills having to be reconstructed; how much danger has there been of this? I did not realize that the danger was coming up so strong. There is, however, another thing to be con-

[1] Engineering News, Vol. 62, 1909, p. 620.

sidered, namely, the number of knots in the timber we get nowadays. I had occasion to look for some timber where Longleaf pine had been called for and something was supplied which was said to be "just as good" but I noticed that the timber was full of knots; the knots of course take up the strength. The reference to the matter of dry rot brings to mind an old house I knew of in Salem, Mass., which is over 100 years old. I do not know what the timber is but it is eaten away on the side with longitudinal tunnels running out in little holes, yet most of the timber is as sound as it can be.

C. J. H. Woodbury. I am very glad Mr. Hoxie has emphasized the importance of contagion from the germs of decaying timbers. Only within the last month, there were two instances in my practice in which I was obliged to insist that decayed timber should be burned at once, to get it out of the way quickly, because if it were cut and stored elsewhere where it could be used for kindling, it would injure other sound timber which composed part of the storehouse. The decay in the solid ends of beams in mill walls was considered more than 30 years ago by the late William B. Whiting, by his advocacy of ventilating the ends of such timbers, at a time when the usual practice sealed them up so as to make a better architectural appearance on the inside. There is one type of defect, not so prevalent as a broken beam or collapsible column, but germane to the general scope of this paper and that is a basement floor which is subject to rapid decay, which difficulty has been conquered by the use of air slacked lime. In a mill at Claremont, N. H., a basement was blasted out of a seamy rock which was teeming with water leaching from the canal above and it was covered by a floor which lasted for many years, merely by using the pieces of rock which had been blasted away as a sub-foundation for the floor and providing suitable drainage; upon this a quantity of air slacked lime was placed and the floor was sound at the time of my last information. Another instance occurred in a mill in Waltham over a cement basement floor put down in 1854 and the beams on which the floor rested for nailing strips, decayed to a brown powder, but the spruce planks painted on the bottom side with hot coal tar resisted decay. These lasted while several hardwood top floors were worn out and removed, and were found 35 years later when the whole floor was removed. In a machine shop in Philadelphia, the basement floor was laid on spent molding sand with a space of 2 in. between the top grade of the sand and the inside of the floor. Holes were bored in this underfloor and the space filled with melted resin poured through funnels; this floor lasted many years.

E. V. French. I want to emphasize what is really the revolutionary character of the information which Mr. Hoxie has brought to us. He shows that practically all of the old requirements as to timbers cannot be used safely today so that new specifications must be made in keeping with the new facts. Most of the old slow growth timber with its large percentage of resin is exhausted. It will be several generations before timber of this kind will grow again, so that for many years inferior timber which is susceptible to dry rot will have to be used. To make such timber safe Mr. Hoxie's data show that it must be treated with some preservative to avoid rapid decay. It is, of course, feasible in new work to use timber which has been treated, but this is only a part of the problem, for with the increase of humidity in old mills, due to the modern manufacturing requirements, timbers which have remained sound for years have decayed rapidly. Recently in a mill 75 years old, white pine beams, which must have dried out thoroughly years ago, were found to be seriously impaired by dry rot. The cause was evidently the material increase in the humidity maintained in these rooms in recent years. This condition may be very serious from the fire standpoint. We have laid great emphasis on the slow burning character of plank and timber construction, but a beam with its center decayed may have but a thin shell of sound wood which will be weakened after a short fire and allow large sections of floor to fall. We do not wish to raise fears, but we must recognize that in these directions there are new conditions of vital importance affecting all such construction.

Charles T. Plunkett referred to the following statement of the author: "The question of primary importance is whether the wood is resistent or susceptible to fungus," and called his attention to the fact that he had not suggested any method for use in judging whether it is susceptible or resistant.

The Author. In reply to Mr. Bates, sound wood thoroughly treated with a suitable antiseptic material will probably be found immune from fungus with ordinary mill conditions. Dry rot undoubtedly enters the timbers from the outside, but a very common condition is that in which the timber is already deeply infected when treated. The fungus inside the wood is not destroyed by the thin superficial brush coat. If the lumber is heated sufficiently long in a bath of hot material, the heat may destroy living fungus which is beyond the penetration of the compound. As to the most effective method for treatment, no conclusion has yet been reached. Investigation is still under way, and I hope to be able to present something at a later date. The problem of mill timber is quite different from railway ties or posts.

Answering Mr. Thompson, carbolineum has shown good results when applied to telegraph posts and mine timbers. I should, therefore, infer that it could be expected to act satisfactorily on mill beams where conditions are not so trying. This material in common with other coal tar compounds has the disadvantage of increasing somewhat the combustibility of the timber and leaving a black, greasy surface difficult to paint. Paint on a dry, uninfected beam would tend to keep it dry and sterile and therefore be an advantage. With a moist infected beam the opposite would be the case.

In answer to Mr. Ernst, the thorough treatment of timber by the vacuum process is without doubt desirable for fence posts in order to secure the longest life. With wet or already deeply infected material, I imagine the sterilizing and drying effect of a hot bath would increase the efficiency of the treatment and the increased penetration caused by the vacuum would probably secure a greater permanence. Little service could be expected from any antiseptic superficially applied to wet, diseased wood.

Replying to the question of Mr. Bigelow, as to the extent of the danger from dry rot, Mr. Hoxie stated that he had investigated about a dozen cases of dry rot in the past three years; the damage resulting had been found to vary from a few hundred dollars up to $90,000. Referring to the old house in Salem, Mass., mentioned by Mr. Bigelow, Mr. Hoxie stated that the condition mentioned is probably worm eaten sapwood.

Mr. Hoxie stated that it was probable that the fungi, which Mr. Woodbury mentioned, as dangerous in the decayed timber, were those frequently found in timber lying on the ground, not the dry rot which is proving destructive of mill frames. Referring to the use of hot rosin under the floor quoted by Mr. Woodbury, Mr. Hoxie stated that the heat might have value in sterilizing the lumber. A space around beam ends in walls can admit moist as well as dry air. If the wall is cold and the air in the room contains a high percentage of moisture, the ventilating space will do more harm than good.

In reply to the criticism of Mr. Plunkett, concerning a suggestion of methods for use in judging whether timber is susceptible or resistant, Mr. Hoxie stated that this matter was discussed quite fully in his paper. The percentage of resin appears to be a reliable index of the power of resistance.

CONTRIBUTED DISCUSSION

HERMANN VON SCHRENK[1] (Abstracted). The author has reached some rather startling conclusions, which, briefly stated, are as follows:

a The percentage of resin may be taken as an index of its power of resistance to rot in any one particular piece of hard pine timber.

b The present hard pine timbers obtainable in the market are practically all (as he designates them) "non-resinous."

c All of the pine timber now available has a low resistance to decay, and cannot with safety be used in factory buildings without preservative processes.

The conclusions are so at variance with the actual facts in the case that I deem it necessary to call attention to the obvious errors in the paper.

In regard to resin as a factor in preventing decay, in view of the fact that the author's major contention is based on the relation between resin and decay resistance, one would assume that there would be a good basis for such a statement. The only proof which the author presents is a cultural test made with two pieces of pine wood. He also calls attention to the resin content of some decayed beams shown in Fig. 6. To one familiar with the behavior of fungi, the cultural proof submitted is of no value whatever. The reasons fungi grow on one piece and not on another may be due to the moisture content, to the density of the wood fiber, to the presence or absence of various compounds, and to many other factors not referred to by the writer. The decayed beams shown in Fig. 6 are splendid examples of decayed sapwood, and I have no hesitation whatever in saying that the resin content of the particular wood which decayed probably had very little to do with the fact that this sapwood did decay.

Numerous investigations have been made from time to time with relation to resin and fungus activity. Personally, I am of the opinion that the only function which resin has with respect to fungus growth is to act as a waterproofing material. A piece of pine wood having 10 per cent resin would be very resistant to moisture. Resin of itself is not an antiseptic. This may be illustrated by the fact that even in the most resinous trees wood-destroying fungi grow with the greatest ease. I have shown in numerous instances[2] that one of the first steps in the attack of coniferous wood, containing considerable percentages of resin, is the liquefication of the resinous substance, which advances in front of the growing fungi, and in frequent cases drips from old knots. This subject might be discussed at length (note for instance the high decay resistance of comparatively non-resinous woods like cypress and redwood). One quotation, however, will suffice. Tubeuf, in his treatise on Diseases of Plants, page 62, says, "Resin is in itself not antiseptic," etc. The only so-called antiseptic function which can be ascribed to resin is the physical quality of preventing the entrance of fungus spores and the physical power to prevent the entrance of water. Mr. Hoxie on page 24 refers to a possible analogy between tannin and resin. It seems hard to understand why, if tannin is a preventive for fungus attack in oak trees, resin should exercise a similar function in pine trees. The author's citation of volume 29 is also unfortunate, in view of the fact that no mention whatever of tannin is made in this article. It is unquestionably true that recent experience in various mill construction buildings has shown an increasing percentage of timbers infected with dry rot. I consider it wholly unnecessary, however, to ascribe this to such a problematic factor as the resin content. I have personally examined a good many of the recent cases, and invariably find that where such decay has taken place it has been in timbers having a high percentage of sapwood. Mr. Hoxie shows this in a very striking manner in Fig. 6. It has been recognized for many years that the relative resistance to decay of sapwood and heartwood is very marked. Sapwood decays rapidly and heartwood comparatively slowly. This is of course universally true of timber in which there is a marked distinction between heartwood and sapwood. This is not the place to discuss the reason for this relative resistance. It will be sufficient to point out that it is the *sapwood* factor in timbers which has given rise to recent difficulties, and not the resin factor. The proposal of the author to consider the resin percentage as a standard (p. 25), and his attempt to figure the value of a piece of timber use on the per cent of resin as a basis, is so extreme, that I hardly consider it worthy of refutation. At best, the engineering profession should go slowly before accepting so radical and unproved a suggestion, based as it is upon a comparatively small number of laboratory experiments, which, so far as can be judged from the paper in hand, failed to take into consideration the numerous conflicting factors usually eliminated in such cultures.

The second point brought out by the author is that the hard pine timbers now available are practically all non-resinous. I have looked through the paper carefully for some statement as to what the author means by "non-resinous" pines. The impression given by the paper is that years ago there were a lot of timbers which come under the group of resinous timbers, but that these have now disappeared.

A possible change which might have taken place in the resinous character of the pines during the last ten or fifteen years, which suggests itself to me, is that during that period of time many of the long-leaf pines have been tapped for turpentine, and this possibly may have given rise to an im-

[1] Member of firm, von Schrenk and Kammerer, Consulting Timber Engineers, St. Louis, Mo.

[2] Diseases of Trees, Year Book of Agriculture, 1900, p. 204, plate 23. See also writings by Tubeuf and Hartig.

pression that removing the turpentine from the pine tree makes it less resinous. This is certainly true so far as certain portions of the sapwood are concerned, but it is not true of the heartwood, as evidenced in the report of the Forestry Service Bulletin No. 8.

The resinous materials of the pine tree, which are removed from the tree during the turpentining operations, come from the liquid portions contained in the sapwood resin canals. I am inclined to believe that Mr. Hoxie drew his conclusions from a comparatively small number of sappy pieces; at least I would characterize his generalization as decidedly without foundation. The variable in the resin content of pine timbers is obviously very great, and this is well shown in the analysis which he presents in Fig. 7.

Mr. Hoxie admits that there are still available four species of pine in the South, but he makes the very strong statement that hard pine lumber 12 in. sq., or larger, is not obtainable in suitable quantities without antiseptic treatment. It may be of interest to call attention to the quanity of pine timber still standing in the Southern States. According to the last report,[1] of the United States Bureau of Corporations for 1913 there are still standing in the Southern States 384,000,000,000 ft. of yellow pine timber, which the Bureau of Corporations classifies into longleaf pine and shortleaf pine. Of the 384,000,000,000 ft., 232,000,000,000 ft. are longleaf pine and 152,000,000,000 ft. are shortleaf pine. Referring to the eastern part of the country, it may be of interest to note that the amount of yellow pine still standing in the Southeastern States is as follows, in billions of board feet:

	Longleaf	Shortleaf
Alabama	25.6	12.4
Florida	58.2	0.9
Georgia (part)	18.5	13.2
S. Carolina (part)	4.6	14.6
N. Carolina (part)	2.9	22.7

Assuming now that the longleaf pine available is typical longleaf pine, no proof has been brought forward by the author of the paper that this is less fit for structural use than it was 15 years ago. The resin factor, I believe, can be disregarded entirely. The difficulty of obtaining such longleaf pine timbers as were available 15 years ago is, as the writer admits, largely a matter of specifications. On p. 22 of the paper the author criticizes the American Society for Testing Materials' specification for adopting the terms "longleaf pine" and "shortleaf pine," going to the extent of characterizing this specification as "arbitrary." I would call attention to the fact that the classification "longleaf" pine and "shortleaf" pine is universally adopted not only by scientific authorities,[2] but also by the lumber trade. Reference has just been made to the classification adopted by the United States Bureau of Corporations, in which all southern lumber pines are classified as longleaf pine and shortleaf pine. I would furthermore call attention to the fact that the largest percentage of yellow pine lumber is today being manufactured under the rules of two organizations, the Georgia-Florida Sawmill Association (annual cut about 800,000,000 ft.) and the Yellow Pine Manufacturers' Association (annual cut about 4,500,000,000 ft.). Both of these associations divide all yellow pine into longleaf and shortleaf pine (see their standard grading rules).

It was for the reason that these commercial classifications are practically standard that the American Society for Testing Materials indorsed them. The problem of distinguishing between these two grades is a difficult one. I thoroughly concur with Mr. Hoxie that the line of demarcation between the two is very vague, and almost impossible to establish with any degree of accuracy. The American Society for Testing Materials suggests that the distinction between the two be based on the density, that is, on the number of growth rings per inch. This distinction may not be the best, but can be used when liberally interpreted where a botanical distinction is out of the question. Attention is furthermore called to the fact that the distinction on the basis of density, made by the American Society for Testing Materials, was largely from the standpoint of strength. No specific mention is made as to lasting power, because that factor was taken care of in the specification for bridge materials by separate clauses. Attention is called to the standard specification for structural timber adopted by the American Society for Testing Materials in 1907,[1] in which for No. 1 longleaf pine stringers the specification calls for timbers which show *not less than 80 per cent heart on each of the four sides*, measured across the sides anywhere in the length of the piece. For caps and sills the specification calls for *85 per cent heart on each of the four sides*. In other words, the American Society for Testing Materials' specification calls attention, first, to the necessity of getting denser timber, and to timber free from sap. Similar specifications are in force in the American Railway Engineering Association. The rule quoted by Mr. Hoxie on p. 22 as prime, practically says the same thing. It is somewhat surprising, therefore, to read below this: "This specification for prime quality loses most of its force when applied to pine of the type shown in Fig. 4." Reference to Fig. 4 shows the upper timber to be almost wholly sap, and the lower over 50 per cent sap. Certainly neither of these two pieces could by any possible means come within the specification "prime," or the American Society for Testing Materials' specifications for longleaf pine. The same is true of all of the figures shown on Fig. 6, not one of which would begin to fulfill either of these two specifications.

The chief trouble with a good many of the failures has doubtless been that the purchaser has not given the timber the proper inspection, because with the specifications available, both of the lumber manufacturing organizations and the American Society for Testing Materials, I can see no excuse whatever for anybody putting timbers such as shown on Fig. 6 into a mill of any sort. My main contention is that the writer of the paper has missed the chief point in connection with this discussion, and that is that the important factor in the lasting of yellow pine in buildings is not the resin content of the timber, but the percentage of sapwood allowed on such timbers. In a recent building failure, which I had to examine personally, in which a large number of timbers had failed, the failure was in timbers with a high

[1] Dept. of Commerce and Labor—Bureau of Corporations The Lumber Industry. Part I, Standing Timber, p. 76, 1913.

[2] From the United States Forestry Service, Bulletin No. 108, on Tests of Structural Timbers, 1912, concerning southern yellow pines: "The term 'southern yellow pine' is applied collectively to practically all of the pines of the Southern States which are manufactured into lumber. On the market the manufactured lumber is divided into two classes, longleaf and shortleaf. Material with more than 8 or 10 rings per inch, and containing a comparatively large amount of summerwood and less than 30 per cent. of sapwood, is called longleaf pine; while material with fewer than 10 rings per inch, slow-growing material that is light in weight, and which contains much sapwood, is called shortleaf pine. Commercially, therefore, the terms 'longleaf' and 'shortleaf' are descriptive of quality and have little botanical significance."

[1] Page 191.

percentage of sapwood, and in the practically all-heart timbers there was only one case of decay, and that one was very slight.

If one specifies longleaf pine timbers for buildings, and strictly adheres to the specification, limiting the amount of sapwood, one will find that the timbers available will give just as good service, from the standpoint of length of life, as those furnished in the past. I agree entirely with the author when he says that timbers of the type shown on his Figs. 3, 4 and 6 should under no circumstances be used in factory buildings without preservative treatment. I believe, however, that he has given an entirely wrong picture when he accuses all longleaf pine timber of lack of decay resistance, when such lack is due largely to the amount of sapwood on the timber.

In closing this criticism, I venture to add that many a producer of lumber has been remiss in furnishing sappy timber under a heart specification, and if there is one point which ought to be emphasized with the greatest strictness on the part of engineers, it is that they shall refuse to accept inferior timbers such as those shown on Fig. 6. There has been a marked change in the nature of the timbers manufactured in the southern yellow pine field during the past seven or eight years. When southern yellow pine was first introduced in northern markets, it was almost wholly strictly longleaf yellow pine. The older buildings were almost without exception built of this heart longleaf yellow pine. The early shipments of longleaf pine usually came from Georgia and Florida. During recent years the pine forests of the more northern states have been drawn upon, and large quantities of timbers are manufactured in North Carolina, South Carolina and Virginia. Most of these are shortleaf and loblolly pine, in which the percentage of sapwood is very much higher than in the true longleaf pine. I have had numerous occasions to protest against the acceptance of sappy shortleaf timbers (shortleaf and loblolly pine) for construction purposes, and frequently it has been difficult to make the manufacturers of this class of lumber understand that they will not be acceptable to the engineer where both strength factors and lasting qualities are desirable. Too much stress cannot be laid upon the necessity for care in not only specifying, but also inspecting every piece of pine timber intended for a building in which both strength and lasting qualities are factors. The poor experience obtained in many recent instances, and specifically those to which Mr. Hoxie refers, are without doubt due to the fact that in these particular buildings sufficient care was not exercised in seeing that these inferior pieces were excluded. I have repeatedly criticized the lumber manufacturers for their failure to live up to their end of the contract. I have also repeatedly criticized the laxity which exists among engineers and architects who allow the contractor or lumber salesman to give them sappy loblolly or shortleaf pine where longleaf pine has been specified. It is highly desirable that the very inspection which the writer of this paper despairs of should be strengthened, and that wider publicity should be given to the caution to use only heart timbers, and to be sure that you get heart timbers when you buy them.

Summarizing the chief points in this criticism:

a Resin cannot be taken as an index of the natural resistance to rot of pine timbers.

b There is no basis for the statement that all pine timbers now available are non-resinous.

c Longleaf pine timber is still available in large quantities for acceptable factory construction.

d Where specifications are written for such factory construction, the greatest stress should be laid upon the percentage of sapwood allowed, because it is the sapwood and the sappy pieces which decay. All recent cases, so far as known to me, have been cases of decay of sapwood timbers, and not of all-heart timbers.

e No timber should be put into a building without rigid inspection, to make sure that only such timbers are furnished as are strictly in accord with the specifications.

THE AUTHOR.—Laboratory experiments have been by far the least important factors in my conclusions as to the effect of resin in retarding dry-rot fungus. Beams which have rotted in place seriously in several mills under average mill conditions have been used for most of my experiments. Undoubtedly the most important antiseptic function of resin is its waterproofing action. Further observations are without doubt desirable.

Three references will be found in foot notes on page 24; the last reference shows tannin to be the cause of the immunity in the oak flooring mentioned in the first. This is a discussion of the qualities of pine that rots and of pine that does not rot, not of pine versus cypress or redwood. It is also a question of diseases of mill beams, not diseases of living trees.

Most of the material shown in Figs. 4 and 6 is the conventional longleaf pine and fills the requirements of Bulletin No. 108 of the U. S. Forest Service, as quoted. I must differ with Dr. Von Schrenk as to the sapwood; the percentage is not large and more heartwood than sapwood has rotted. The beam shown in the lower part of Fig. 4 must be longleaf pine, as it is fine-grained; it must be prime quality as it is nearly all heartwood. Nevertheless it is unquestionably rotted. After a timber has rotted it is very easy for almost anybody to say that it was poor material, but it is frequently much more difficult to predict what it will do before it has rotted.

Dr. Von Schrenk states that such timbers as those shown in Figs. 3, 4 and 6 should under no consideration be used without antiseptic treatment. If so, as most of these are conventional longleaf pine, of prime quality, it is logical to infer that all hard pine timber would require antiseptic treatment to assure its lasting qualities.

I think I have not said that there has been any change in the true longleaf pine except the use of its name for other varieties. The statistics quoted, giving an estimate of the conventional longleaf pine standing in the South, do not prove that it will be found more resistant to decay when it is cut into timber than the present lumber supply, which is admittedly less resistant than that of former years.

In the following Dr. Von Schrenck agrees with my statements:

a Hard-pine mill frames erected within the last seven or eight years show greater tendency to rot than those erected earlier.

b The name longleaf pine now has an arbitrary meaning without botanical significance.

c The distinctions between lumber which is conventionally called longleaf and that which is conventionally called shortleaf are vague; much is left to the generosity of the lumber dealer and

the good judgment of the inspector, and lumber dealers are frequently without generosity and inspectors without judgment, accentuating the need of concise specifications.

d True longleaf pine is as good now as it ever was.

e The general run of southern pine is much poorer now than in former years.

But we disagree as to the value of the percentage of resin as an index of the resistance of hard pine to dry rot in mill timber; as to whether or not heartwood is a guarantee of fungus immunity; and as to the necessity of general antiseptic treatment of hard pine for mill frames.

I am not trying to demonstrate that resin as a waterproofing agent, or otherwise, retards the progress of rot. This has been a matter of common knowledge for centuries. What I do want to determine is how much resin is necessary to retard dry rot sufficiently in mill timber to make it reasonably safe for use in mill construction with average conditions. I further want to know what the chances are of getting such resistant lumber from the present lumber market. If it is not practicable to be certain of getting such timber by methods in general use, I want to decide upon an antiseptic treatment which can be practically applied and which will render the poorest varieties of timber sufficiently reliable to be used with safety, so that the mill owner may be reasonably assured that his expensive structure will not be seriously damaged by dry rot in a few years and that a rotted column or beam will not cause an accident which may kill his employees. Any assistance which Dr. Von Schrenk can offer along this line of endeavor will undoubtedly be appreciated by the mill engineers of the country.

MEETINGS

MINNEAPOLIS—ST. PAUL, NOVEMBER 5

Sixteen members of the Society met at the Hotel St. Paul, St. Paul, Minn., on November 5, for the purpose of organizing in that vicinity a branch of the Society similar to those already in existence in ten other cities. The meeting was in charge of Max Toltz, as temporary chairman, and E. J. Heinen, as temporary secretary, and a great deal of interest was shown in the formation of this organization. The election of officers for the year was as follows: the two temporary officers were made permanent, the duty of treasurer being added to that of secretary, and Mr. C. L. Pillsbury was chosen as vice-chairman. The name of the organization was definitely decided upon as the "Minnesota Branch of The American Society of Mechanical Engineers."

Plans for the Spring Meeting of the Society, which is to be held in the Twin Cities, as decided at the last Spring Meeting in Baltimore, were also set on foot by the election of an executive committee consisting of the following members: Oliver Crosby and Henry LeR. Brink, of St. Paul; John J. Flather and Wm. H. Kavanaugh, of Minneapolis; T. W. Hugo, of Duluth, and Messrs. Toltz and Pillsbury, members ex-officio.

PHILADELPHIA, DECEMBER 10

The meeting of the Society in Philadelphia, on December 10, was preceded by a dinner at the Engineers Club, at which the Committee on Meetings in Philadelphia entertained the speakers of the evening, Messrs. Morris Llewellyn Cooke, Mem.Am.Soc.M.E.; J. B. Lichtenberger; Lewis H. Kenney, Mem.Am.Soc.M.E.; Calvin W. Rice, Secretary of the Society; Henry Hess, Manager of the Society; and John Price Jackson, Mem.Am.Soc.M.E., and Commissioner of Labor of the State of Pennsylvania.

The first paper of the evening was read by Mr. Kenney, who chose as his subject, How far shall Judgment be exercised in the Interpretation of Engineering Specifications. The author is draftsman-in-charge of the machinery division of the Philadelphia Navy Yard. Mr. Cooke, who is director of the department of public works of the City of Philadelphia, read the second paper, and Mr. Lichtenberger, lawyer and lecturer on business law at the University of Pennsylvania, the concluding paper. An interesting discussion which was participated in by Messrs. Rice, Hess, Jackson, Henry H. Quimby, Thomas C. McBride, Mem.Am. Soc.M.E., and Inspectors Wheeler and Willits, closed the program.

ST. LOUIS, DECEMBER 13

The annual meeting of the St. Louis branch of the Society was held December 13, 1913, at the Mercantile Club. Thirty-eight members and guests were present, Prof. E. L. Ohle presiding. John Hunter, a member of the Committee on Meetings in St. Louis, who has recently been elected one of the Managers of the Society, was present and received the good wishes and congratulations of his friends; R. H. Tait told in a few fitting words of the esteem and honor in which Mr. Hunter was held in the engineering profession and said that the St. Louis members felt great pride in the honor that had come to one of their number. Mr. Hunter in reply reviewed some of the important incidents in his career on both land and sea, drawing attention to the great strides that have been made in steam engineering during that period, especially in steam turbine units.

Mr. Gustafson, superintendent of the Rankin School of Mechanical Trades, gave an interesting account of his trip in Europe last May, when he investigated the important trade schools on the Continent. He said his work was greatly facilitated by the assistance he received from Prof. Conrad Matschoss of the Verein deutscher Ingenieure, whom he had previously met when on a visit to this country last spring. H. Wade Hibbard, Mem.Am.Soc.M.E., gave an interesting account of the Annual Meeting of the Society, and urged all who could to attend these meetings in the future.

BOSTON, DECEMBER 18

A joint meeting of the Boston Society of Civil Engineers, and the Boston sections of the American Institute of Electrical Engineers and of this Society was held at the Engineers Club, the program being in the hands of the Electrical Engineers. Mr. B. A. Behrend, Mem.Am.Soc.M.E., gave an illustrated lecture entitled, A Great Engineering Disaster and the Lessons Learned Therefrom. The talk was a very entertaining and profitable one.

NECROLOGY

VICTOR HUGO

Victor Hugo was born at Kingston, Ontario, November 20, 1873. He was the son of T. W. Hugo, Mem. Am. Soc. M. E., who in 1881 moved with his family to

Duluth, Minn. Victor Hugo received his engineering education at the University of Minnesota, from which he was graduated in 1896 with the degree of M. E. He began his career as assistant to his father, consulting mechanical engineer of Duluth, in July, 1896, and two years later entered the Chicago inspection force of the Hartford Company. Late in the following year he was transferred to St. Louis, and shortly afterwards was appointed chief inspector of that department. On January 1, 1905, he was promoted to the position of manager, a position he held till his death on January 31, 1913.

ANDREW MARTIN SCHREUDER

Andrew Martin Schreuder was born in Syracuse, N. Y., October 17, 1874. He obtained his early education in the public schools of that city and his technical training at Cornell University, where he was graduated in 1897. He was subsequently connected in various capacities with the Geo. M. Newhall Engineering Company, the Tabor Manufacturing Company and the Woodbridge Manufacturing Company. In 1908 he became associated with the Philadelphia Textile Machinery Company, at the time of his death, January 1, 1913, being its superintendent and chief engineer. He had developed designs for and successfully built and installed a number of the largest dryers in operation and was engaged in the development of dryers for explosives and inflammable materials.

He was a member of the Cornell Club and of the Franklin Institute of Philadelphia.

WILLIAM OLIVER WEBBER

William Oliver Webber was born at Springfield, Mass., January 4, 1856, and was educated at the public schools of Manchester and Portsmouth, N. H., and of New York. He served his apprenticeship at the Manchester Locomotive Works from 1871 to 1874, and since then has served in engineering capacities in the locomotive department of the Boston & Maine Railroad Company; with the Toledo, Peoria & Warsaw Railroad Company, Peoria, Ill.; with the United States Centennial Exposition, Philadelphia, in 1876; in the test department and laboratory of the Chicago, Burlington & Quincy Railroad Company, Aurora, Ill. In 1881 Mr. Webber was made superintendent of the Allen Paper Car Wheel Company, Pullman, Ill., and six years later, commissioner of Abolition of Grade Crossings in Massachusetts. He relinquished this position one year later to accept the superintendency of the Erie City Iron Works. Since 1894 he has been a consulting engineer in the firm of Webber & Smith, Mechanical, Hydraulic and Dynamic engineers, of Boston. He acted as expert in the United States and Circuit Courts.

Mr. Webber had been a member of the Ancient and Honorable Artillery Company since 1884, and engineer officer of the First Brigade Staff, United States Navy, from 1901 to 1904. He was a member of the Boston Society of Civil Engineers, the Society of Colonial Wars, United States Military Institute and the United States Naval Institute. He died January 9, 1913.

WILLIAM H. LEACH, JR.

William H. Leach, Jr., was born in Brooklyn, N. Y., September 4, 1873. He received his technical education as a mechanical engineer at the Massachusetts Institute of Technology, being graduated in 1897. Immediately upon graduation he entered the employment of the Union Metallic Cartridge Company of Bridgeport, Conn. During his fourteen years of service there he acquired an intimate knowledge of many of the manufacturing processes used in the fabrication of the companies' products; he designed machines for manufacturing primers, and for packing them, loading and packing cartridges, machines for weighing powder charges and delivering them into their cartridge shells, loading apparatus for rapid-fire ammunition, etc. His work consisted also of laying out and setting up machines, and systematizing the work in the engineering department. During the last two years of his business life he was research engineer for the company and was considered one of the foremost experts on ammunition in the country. He died in Newton, Mass., September 6, 1913, after an illness of two years.

GEORGE HAMPTON SMITH

George Hampton Smith was born in Pittsburgh, Pa., September 29, 1878. He attended the public schools of Pittsburgh and immediately after graduation from high school entered the Carnegie Steel Company where he was under the direct supervision of James Scott, superintendent of the Isabella and Lucy furnaces of the Carnegie Steel Company, Pittsburgh. His experience covered all phases of blast-furnace work, including the drafting room, and in this manner he gained a wide and thorough knowledge of blast-furnace construction. He was graduated in 1910 from the Carnegie Technical Schools in mechanical engineering and in 1911 was made assistant to the chief engineer under Mr. Scott at the steel works. In this capacity he had charge of practically all the construction and drawing room work in connection with the building of modern thin lined water-cooled furnaces with which he had great success. At the time of his death, May 20, 1913, he was engaged in remodeling the stacks of the Carnegie company's Edgar Thompson works at Braddock, Pa.

Mr. Smith was a member of the Railway Club of Pittsburgh, and president of the Council of Aspinwall, where he had made his home for the past ten years.

OPERATION OF LARGE BOILERS

NOTES ON THE FURTHER OPERATION OF LARGE BOILERS OF THE DETROIT EDISON COMPANY

BY J. W. PARKER, DETROIT, MICH.

Junior Member of the Society

AT the December 1911 meeting of the Society, Dr. D. S. Jacobus presented a paper[1] giving the results of the first performance tests on the 2365-h.p. Stirling boilers at the Delray generating plant of the Detroit Edison Company. At the time of his tests three of these boilers were in service, one having been run about 18 months and the others nine months. Since that time six more of the type have been installed at the rate of two a year, the last two in the autumn of 1913. It is the object of this paper to present some report of the everyday experience in operating all these boilers.

Reliability. That a boiler unit can be made so reliable that it may in this respect be classed with the turbo-generator, has been the experience with the nine boilers installed at Detroit. Table 1 shows the performance of six of these units during October, November and December of 1912. This period was selected as being the time when reliability was essential on account of the plant load conditions. The load curve of the plant shown in Fig. 2 is typical. At no time was it compulsory to put a boiler out of commission; at no time was any boiler out of commission during the peak load of the day, from four o'clock to six o'clock in the afternoon. Of the 215 hours the three Taylor stoker-fired boilers were taken out of commission, but 89 hours occurred during the five peak days of the week, Monday to Friday. This time was employed in cleaning furnaces, repairing stokers and inspecting tubes externally. The boilers themselves proved to be 100 per cent reliable.

Possible Cause of Trouble. The causes which might take boilers out of commission at times when they are needed for service, are being eliminated. There are three sources from which to expect trouble: (*a*) the boiler proper, (*b*) the furnace brickwork, and (*c*) the stoker.

(*a*) The boiler itself need be no hazard. Fittings and flanged joints, if properly watched and followed up, do not cause shutdowns. The same is true of the tubes, which are seamless. From October 15, 1912, to November 1, 1913, there have been but two tubes replaced in seven boilers whose average age is two years. One front tube was taken out after the discovery of a small bag next to the fire, which was found during a periodical external inspection of the front tubes during furnace repairs. The other tube was in the back row and was spoiled by a mishandled turbine tube cleaner. Its condition was discovered while the soot was being blown from the heating surfaces by hand blowers. However, the leak was very slight and the boiler was not cut out of service until night.

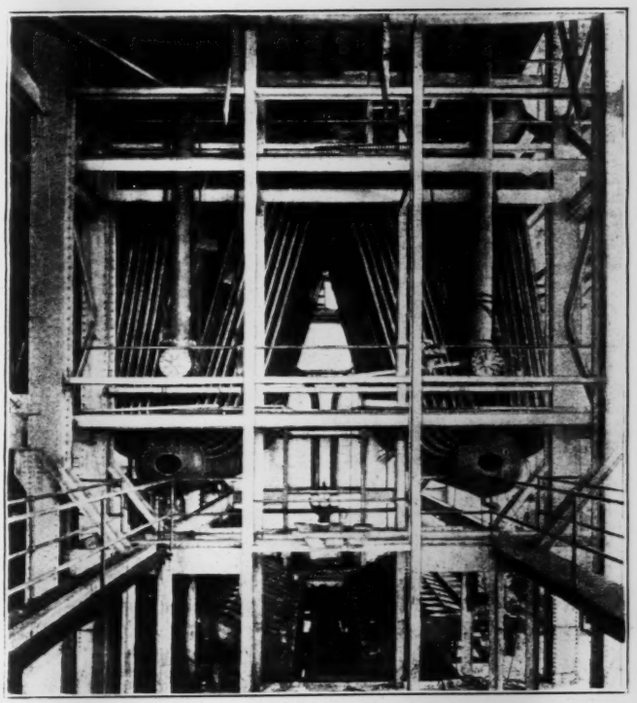


FIG. 1 GENERAL VIEW OF 2365-H.P. BOILER AND STOKER BEFORE BEING BRICKED UP

The plant is using about 8 per cent of make-up water, and although Detroit River water at Delray is not considered bad for boilers, nevertheless, a sulphate scale about 1/16 in. thick forms in the hot front tubes. These front surfaces are worked exceedingly hard and scale of even 1/16 in. thickness may make trouble. A soft piece of mud lodging on top of the hard scale is likely to cause a small bag. This trouble can occur only in the lower bends of the first row tubes, where loose dirt sometimes lodges.

Tube trouble will be practically eliminated by the use of pure water. The make-up water is now river water, treated with enough barium hydrate to neutralize the sulphate content. The percentage of make-up

[1] Trans. Am. Soc. M. E., vol. 33, p. 565

Presented at the Annual Meeting, December 1913, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

can be reduced to between 2 and 3 per cent by avoiding the necessity of blowing down boilers. It is seriously contemplated to use distilled water for make-up. There seems to be a lack of evidence that distilled water is of itself corrosive. The cost of distilling would be almost negligible, since the heat required to evaporate the raw water would be kept in the system by using

TABLE 1 SHOWING TIME BOILER UNITS WERE OUT OF COMMISSION

	Boilers Nos. 25, 27 and 33 Taylor Stoker		Boilers Nos. 26, 28 and 30 Roney Stoker	
	Hours	Per Cent	Hours	Per Cent
Total Number of Boiler-Hours (3 months)	5160	....	6624	....
Number of Boiler-Hours out of Service (cleaning)	298	....	323	....
Total Number of Boiler-Hours available for Service	4862	....	6301	....
Total Steaming Hours	3178	65.4	3594	57.0
Total Banking Hours	1469	30.2	1764	28.0
Out of Service at Night	26	0.5	....	....
Out of Service at Week End	100	2.1	219	3.5
Out of Service for Week-day Repairs	*89	1.8	†724	11.5
Total	4862	100.0	6301	100.0

* Cleaning Furnace, Inspecting Tubes and Repairing Stoker, 89 hours.

	Hours
† Repairing Stoker	537
Repairing Furnace Wall	173
Packing Blowoff Valves	14
Total	724

main turbine condensate for cooling water in the distillation process. To safeguard against any possible boiler corrosion, enough soft scale forming material would be introduced into the feedwater to cover the heating surfaces with a thin protecting scale.

(*b*) Furnace brickwork is with the underfeed stoker reduced to a minimum as evidenced by Fig. 3. It consists of the four furnace walls and nothing more. Much work has been done to make these walls stand up. It has been necessitated on the ground of maintenance cost only, however, since if certain sections of the furnace are rebuilt once a year, there is no chance for sudden trouble which would cause a shutdown. There has been no such sudden trouble.

(*c*) The stoker remains to be considered. The fallibility of the stoker is not great. Repairs ordinarily made are the replacement of tuyeres, dump plates and the like which have burned out. The work, mentioned in later paragraphs of this paper, which has been done to decrease stoker maintenance costs has, as in the case of brickwork, made it unlikely that the boiler need ever be taken out of commission for this cause, except when the plant load conditions permit it.

There have been cases of sudden stoker breakdown, sometimes occasioned by the introduction of chunks of iron or wood into the stoker rams, along with the coal. Also, there have occurred once or twice, serious burn-outs of tuyeres and other grate surfaces extending over an area of 5 or 6 sq. ft. In these instances, the fire can be, and has been, banked on the one side of the furnace where the trouble exists and the other half of the furnace operated to get half capacity from the boiler. This one-side firing is entirely practicable.

To sum up, the experience has been this: the boilers were ready for service 95 per cent of the time considered; they were ready 98 per cent of the five full load days of the week; and ready for service 100 per cent of the time during the peak load periods. It is to be assumed that the boilers must be down for ten days or two weeks at nine or ten month intervals for boiler

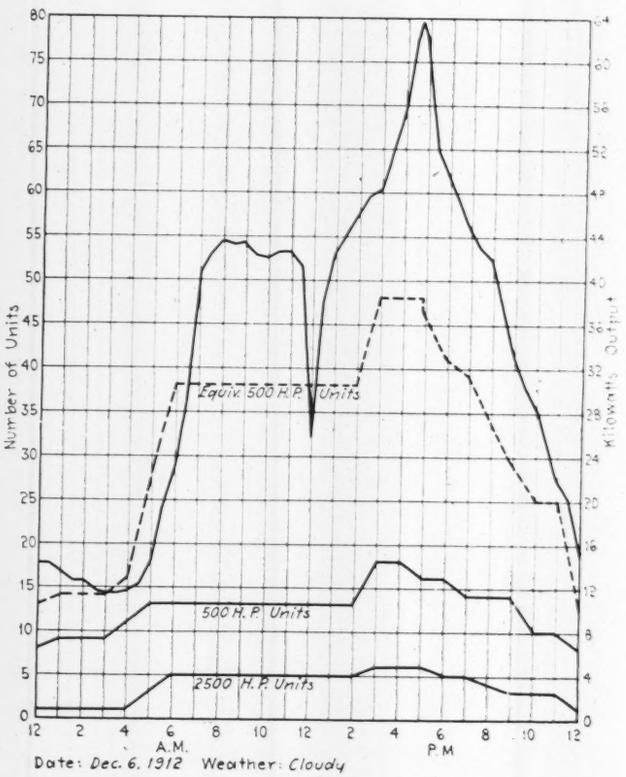


FIG. 2 PEAK LOAD CURVE, DECEMBER 6, 1912

cleaning and a general overhauling of stokers and brickwork.

Recent Design. On the above considerations, the Detroit Edison Company is now building a power plant to contain six 20,000-kw. turbines served by 12 of these 2365-h.p. boilers, which is two boilers to one turbine, with no spares, or 10,000 kw. per boiler. Although the chances of losing the capacity of any boiler by a forced shutdown are remote, they have nevertheless been considered. At normal full load on a given turbine unit, the two boilers will operate at approxi-

mately 191 per cent of the builder's rating based on 10 sq. ft. of heating surface per boiler horsepower. If, with six boilers running at this rating, one boiler should go completely out of commission, the other five would have to carry the entire load of 60,000 kw. and thus operate at 235 per cent of rating, which is perfectly possible. As a matter of fact, the settings and auxiliaries are being designed to allow of continuous operation at 255 per cent of rating, which would enable three boilers to take the full load of four, i. e. 40,000 kw. Very recently, one of the Delray boilers was isolated from the rest of the plant with a 15,000 kw., seven-stage Curtis vertical turbine, and over 11,000 kw. was carried for an hour without difficulty.

Flexibility. The over-all boiler and furnace efficiency of the Taylor stoker-fired unit tested by Dr. Jacobus is shown by Fig. 4. The curve is a straight line throughout the range tested, having a gradual slope from 80 per cent efficiency at 93 per cent of rating, to 76 per cent efficiency at 214 per cent of rating. It is economical, therefore, to run as many boilers as possible at about 90 per cent of rating when the plant load is light, and then carry the peak of the load by increasing the rating on the boilers. This is our present practice. In this way, from morning till night there need be no fires banked or broken out of bank, and the firemen can bend their energies instead to manipulating their fires to the best advantage.

This flexibility is at no time more convenient than in summer when provision must be made for a sudden peak load due to a thunderstorm. At Delray, in the summer of 1914 the average day load will be about 63,000 kw., while provision must be made for a storm load of about 82,000 kw., a 30 per cent increase. Boilers ordinarily running at 100 per cent or 125 per cent of rating (a very economical point) will take a 30 per cent increase in load with very little effort. No banked fires will be carried during the daytime.

Control Methods. A boiler of such output assumes enough of importance and individuality, so to speak, in a 120,000-kw. plant to gain for itself unusual attention from the man who is firing it. One fireman fires two units. The control of each unit is brought directly under his hand in every way possible, so that a minimum of time will be wasted in mechanical manipulation. Fig. 5 is a view of the gage board and control point for one boiler. A water tender stationed on a gallery at the top drum level feeds the boiler but the fireman does everything else in the way of operating. The boiler dampers are shifted at the control point, and the throttles of the blower turbines are extended through the floor, the valve stand being seen in the view, near the gage board. The stokers are motor driven and one of the controllers is located on a steel column 6 ft. away from the gage board; the other could have been brought around also, but it was thought unnecessary, since a man must walk around to the stoker on the distant side to watch it and to study his fire. The control point of the opposite boiler is located just across the aisle from the first.

The plan is for one man to operate two stokers, and in addition, to have a head fireman in charge of from six to eight units, whose duty it is to oversee all the fires, and go to the assistance of any fireman who needs help. On the gage board are mounted steam gages showing pressure at the superheater inlet and superheater outlet and draft gages showing air pressure under the fire, draft at the damper, and draft at the top of the combustion chamber. There is also on this board the record dial of a CO_2 meter. The meter itself

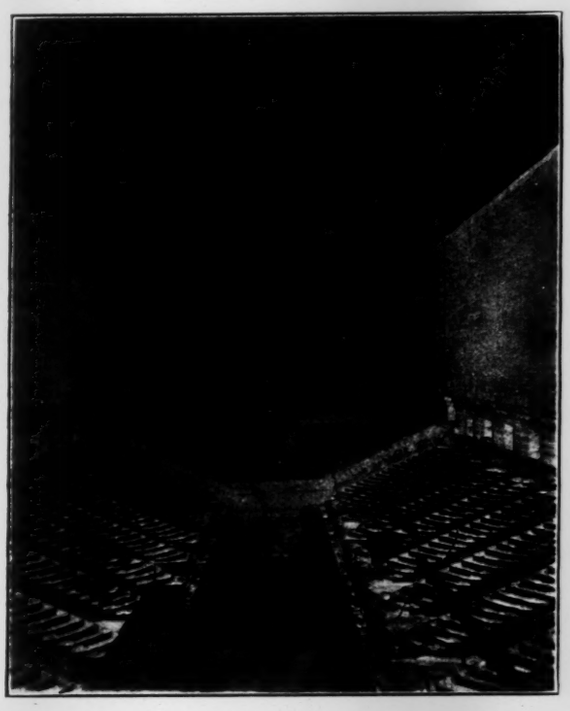


Fig. 3 Inside View of Furnace with Taylor Stoker

is mounted on a gallery 15 ft. above the boiler room in a position central of four boilers. Four samples of gas are drawn from one furnace, automatically mixed, and the resulting analysis is recorded where the fireman can watch it.

Fireroom Personnel. The whole idea is to employ the most expert firemen it is possible to develop, and give each man control of the burning of a very large amount of coal. It is economical to employ a fine type of man and pay him an expert's pay. The present first-class fireman's pay is 40 cents an hour and he is well treated as to vacation and sick leave. These men are given the benefit of whatever boiler testing is done, and a force of firemen is being built up that can obtain remarkable results with their fires. They are acquiring an intelligent working understanding of the combustion of coal. At the same time the unit cost of firing will be unusually low. The Table 2 is a schedule

of the labor necessary to handle 12 boilers of a six-turbine plant with no economizers installed.

The number of men allowed for such a plant is ample as shown by long experience at Delray. The cost per day is 55 per cent as much as the firing cost in a neighboring manufacturer's plant equipped with 24 278-h.p. Babcock & Wilcox boilers fired by overfeed stokers and equipped with economizers. In this plant it was found that maximum boiler and furnace efficiency was obtained while running the boilers at 95

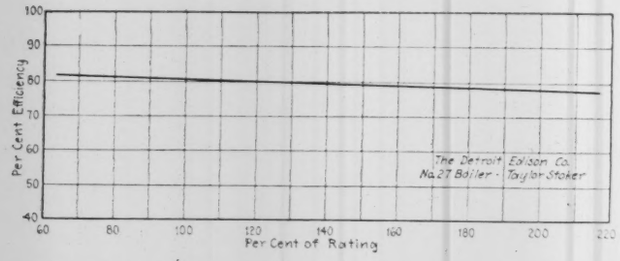


FIG. 4 CURVE SHOWING OVER-ALL EFFICIENCY OF BOILER AND FURNACE AT DIFFERENT RATINGS—TAYLOR-STOKER FIRED UNITS

per cent of rating, and, with a load factor of nearly 100 per cent, it was considered economical to operate at that rating. In order to make a comparison of the cost of firing large units and small units, it has been assumed that the small boilers could be operated over the same range as the large ones. At the same time it has been assumed that both plants operate with the same load factor. The comparison is greatly in favor of the large unit, notwithstanding the fact that the scale of pay on these boilers is much higher than that on the 278-h.p. boilers. It is to be noted that the load factors are for monthly periods.

TABLE 2 LABOR COST OF FIRING A 12-BOILER PLANT

Maximum load..... 120,000 kw.		12 boilers at 191 per cent	
Minimum load..... 20,000 kw.		4 boilers at 96 per cent	
Monthly load factor (November).....			46 per cent
Operators employed—			
Morning shift	6.30- 2.30	2 head firemen at 45 cents .	$7.20
		6 firemen at 40 cents.....	19.20
		2 watertenders at 35 cents...	5.60
Afternoon shift	2.30-10.30	2 head firemen.....	7.20
		6 firemen.....	19.20
		2 watertenders.....	5.60
Night shift	10.30- 6.30	6 firemen.....	19.20
		1 watertender.....	2.80
			$86.00
Boiler room foremen.....			15.00
Total cost per day.....			$101.00
Cost of firing boilers—cents per kw.-hr.....			0.0076
Actual cost in a neighboring manufacturing plant's boiler room to generate an equal amount of energy but at 100 per cent load factor.....			$169.00
Estimated cost in neighboring manufacturing plant's boiler room if load factor is 46 per cent (allowing 191 per cent maximum boiler rating).....			$182.00
Scale of pay—watch foreman.....			31½ cents per hour
firemen.....			25 cents per hour

Pilot Steam Gage and Indicators. At the end of each firing aisle is mounted a large pilot steam gage. The dial is graduated in divisions of 1½ in. on its circumference but with no figures, and each scale division registers 1 lb. per sq. in. It is found and marked at just what point on this sensitive gage the boiler safety valves will lift and the steam pressure is carried accordingly. On the same gage board with the pilot gage are a clock and the dial of a load indicator, operated from the switchboard gallery, indicating the load on the entire plant in kilowatts. In handling his fires, the fireman is guided in the first place of course, by steam requirements as shown by the pilot gage and a steam flow meter. The air pressure under the fire and the stoker speed are controlled by hand.

Variable Stoker Speed. As before mentioned, the stokers are driven by motors. These are direct-current

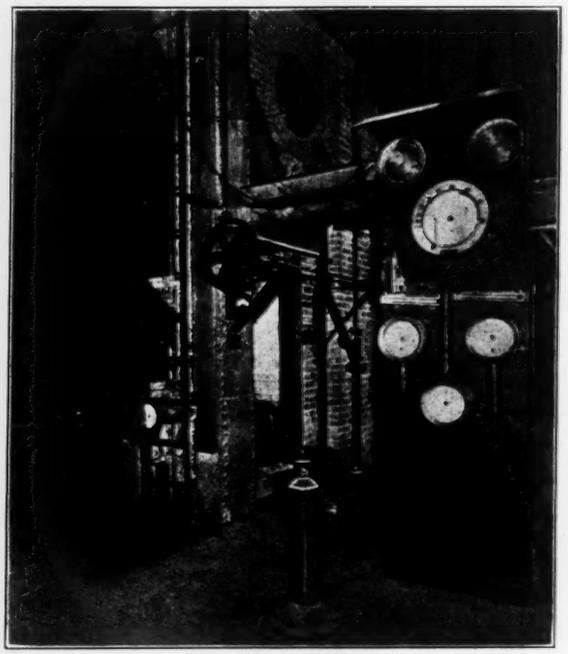


FIG. 5 GAGE BOARD AND CONTROL POINT FOR ONE BOILER UNIT

interpole machines with a speed control by field resistance of four to one, and with 18 running points on the controllers. Indicating dial tachometers are being installed on the stoker shafts, so that the stoker speed for a given load may be watched carefully. An immense advantage is gained by being able to run the stoker at any given constant speed. The amount of power required to drive the stokers is extremely variable, and it is difficult to make a steam stoker engine govern under these conditions with a controlled range of speed variation of four to one.

As to furnace conditions, the firemen must judge by the CO_2 recorder, by the amount of air pressure necessary for any given boiler load, and by no means least of all by the color of the gases as they tumble over the

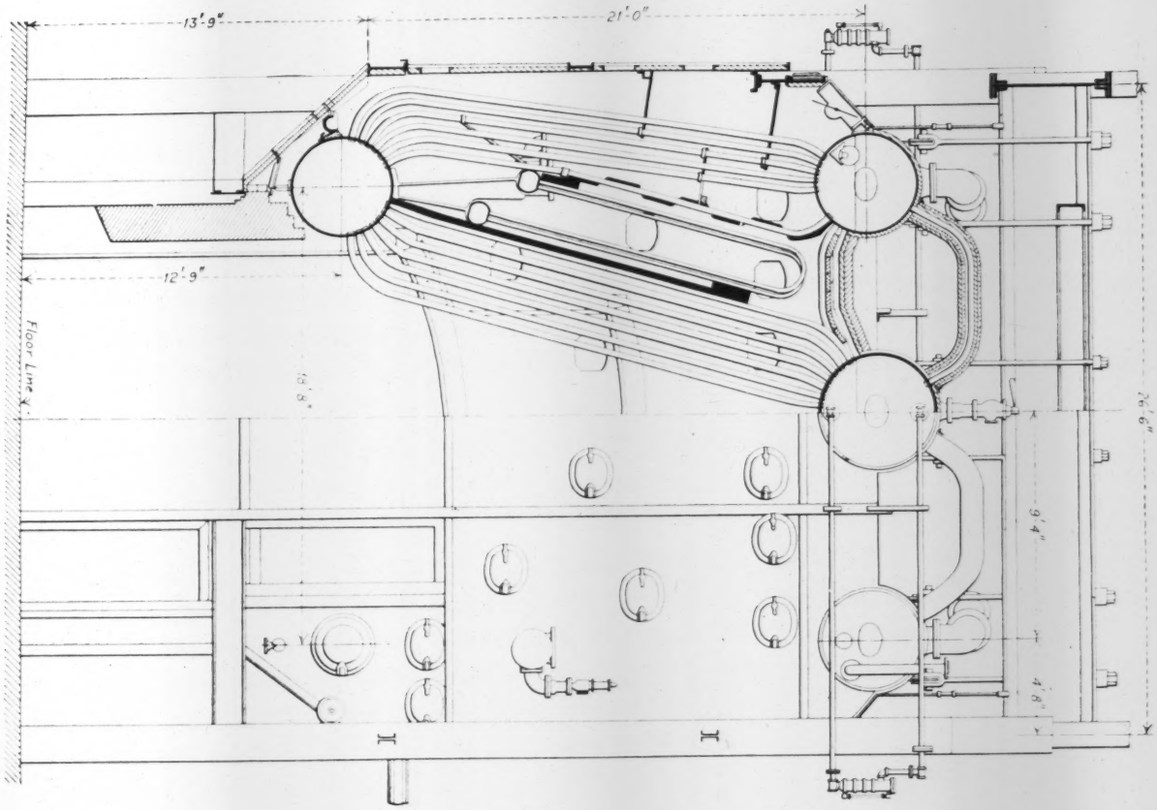


Fig. 6 End Section of Boiler showing Arrangement of Gas Passes

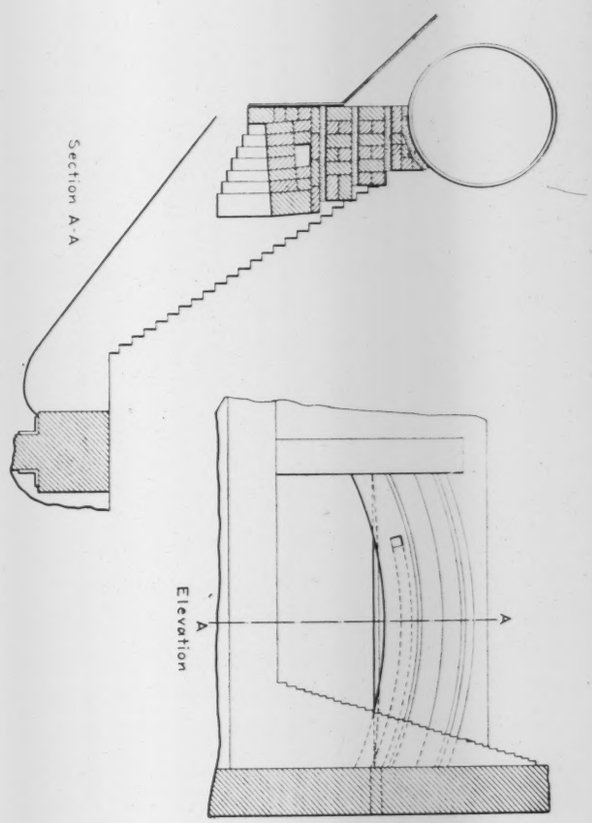


Fig. 7 Drawing of Arch for Roney Stoker

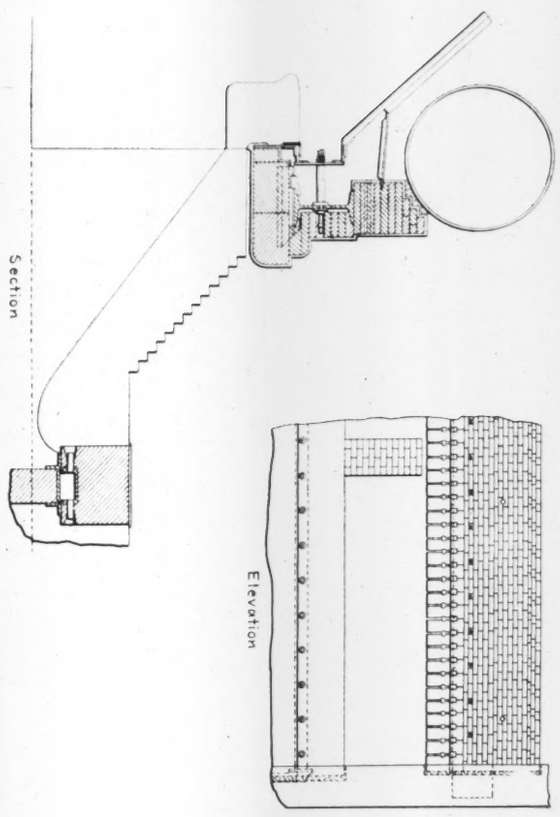


Fig. 8 Drawing of Flat Arch for Roney Stoker

first baffle and enter the top of the superheater pass, Fig 6. A reflecting observation device for this is at present being tried out, which allows the fireman to look into this boiler pass from a position near his gage board, instead of, as now, being dependent for this valuable indication on observation by the watertender or foreman.

Possibilities of Automatic Control. It is a question not yet entirely settled whether it would or would not be better to forsake hand control of these boilers for automatic control. It has been suggested that feedwater regulators be used and that some automatic steam pressure governed apparatus control the air pressure under the fire and the stoker speed. That is not necessitated by labor cost; neither by the need of

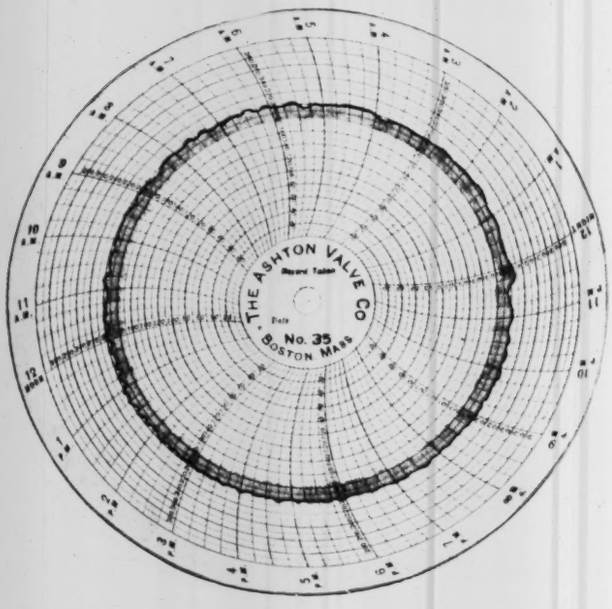


Fig. 9 Steam Pressure Chart, January 7, 1913

steam pressure regulation, as is evinced by the reproduction of the steam pressure chart in Fig. 9; this chart covers January 7, 1913, a day with wide variation of load. Our prejudice, if not our final judgment, is against automatic control.

As for feeding the boiler, a skillful water tender learns not to touch his feed valve except at rare intervals and when the load on the plant becomes steady, the steam flow is continuous also. One automatic feedwater regulator was experimented with. It was not a success, due in most part to a peculiarity of this type of boiler. On account of the rapid circulation, the water in the top middle drum stands at times as much as 2 ft., or more, higher than in the two outside drums, although the three are connected with water circulating tubes as well as by steam circulators and the main boiler tubes. The water columns are piped to the center drum, there being often no indication whatever of water in the outside drums.

The water level as shown in the glass under the above conditions, naturally, is variable, being a function of the rate of steaming. This being the case, it is easy for a feedwater regulator, automatically attempting to hold a constant level in the center drum, to get into difficulties whenever the demand for steam varies sharply, as it will, when the plant load is changing at noon or during the peak load of the day. When the steam demand decreases slightly, the water level may fall possibly an inch, being very sensitive. If the regulator immediately opens and starts feeding more heavily, the circulation will be still further decreased, and then the water level will fall lower and the regulator feed still more heavily. The steam output of the boiler will decrease rapidly with this, until the regulator begins to close again. The steam output will now begin to increase and the water level rise also and presently close the regulator entirely; a typical "hunting" action is thus set up. Some type of regulator can undoubtedly be worked out so as to handle these boilers; but it is questionable whether it would be worth while, when one water tender can tend water for a 60,000 kw. load.

Automatic Control of Fuel and Air. There remains the matter of handling coal and air feeds. In a small plant owned by the Detroit Edison Company, eight stokers are controlled automatically, both air and coal feed being independent of the fireman. The latter is not allowed to touch the stoker adjustments except to change the steam pressure one way or the other. This is going to the extreme, but it is not an uncommon method of firing underfeed stokers. It certainly does not tend to develop intelligent firemen nor obtain very satisfactory furnace efficiencies.

It is not desirable to substitute an automatic air and stoker control if a better CO_2 chart cannot be shown thereby. The danger is that the fireman will rely on the automatic device, rather than study conditions and control his fire intelligently. With the present hand control, excellent furnace conditions are being obtained and held. Observation of the furnace gases, as they enter the superheater pass from the top of the combustion chamber, shows that the combustion of volatile gases is entirely complete and that the operation is consequently smokeless. At the same time, the CO_2 charts show remarkably good results, 15 per cent of CO_2 being very common, the average being about 13.5 to 14 per cent. Repeated analyses made with an Orsat apparatus check these recording machines and at the same time discover no more than from a trace to 2/10 of a per cent of carbon monoxide.

Good conditions are most often disturbed by the periodic dumping of the ash and refuse from the stokers. There is now being tried out a continuous dumping device, a revolving grate, which bids to be very successful. It will undoubtedly go far toward

enabling the fireman to produce service results as good as those shown during tests.

Maintenance Costs. A careful study was made for four months in 1911 and 1912 of the maintenance costs of the boiler units fired by underfeed stokers and the figures are presented in Table 3. Since the period selected includes one job of general overhauling of a stoker and setting, it is conservative to estimate the maintenance cost for a whole year from these four months. This allows for the overhauling of boilers at intervals of eight months on the average, which is the present practice in the Delray plant. In this way the annual cost per kw.-hr. generated has been estimated, which includes maintenance of stokers, settings and boilers.

TABLE 3. MAINTENANCE COSTS OF TWO 2365-HP. BOILER UNITS WITH TAYLOR STOKERS.

INCLUDING REPAIRS TO BOILERS, STOKERS AND BRICKWORK

	Boiler No. 25	Boiler No. 27
December 1911—Hours steaming	442	447
Cost of material and labor	$116.00	$112.60
January 1912—Hours steaming	483	490
Cost of material and labor	$84.86	$2.88
February 1912—Hours steaming	464	462
Cost of material and labor	$63.35	$77.74
March 1912—Hours steaming	424	182
Cost of material and labor	$1.71	$253.02*
Cost per kw.-hr. in 12 boiler installation, with two boilers for one 20,000-kw. turbine (yearly load factor 36 per cent)	0.0034 cents	

* Covers general overhauling of stoker and setting.

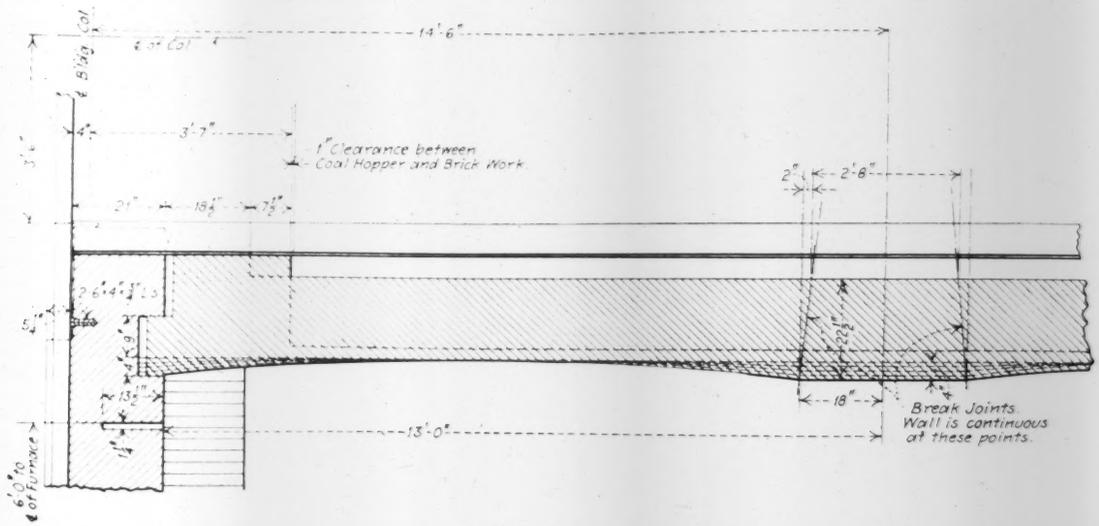


Fig. 10 Details of Vertical Arch Construction of Furnace Walls

This maintenance has, as a matter of fact, decreased since the time referred to, because of improvements worked out on the stoker dumps. The dumping plates have now been made with removable tops, so that only the part burned need be removed and the web of the casting may be left in place. By a redesign of the shape of these dumping sections only one pattern is made use of, and the labor cost of replacing burned parts has been greatly reduced at the same time. In 1912, one stoker was completely rebuilt in order to experiment with various changes of design, especially of dumps, which have required most frequent renewal.

Setting Repairs. The settings of these boilers consist, as was stated before, simply of four walls without arches or bridge walls. (See Fig. 3.) The only brick repairs necessary thus far with this setting have been the annual rebuilding of part of both front walls (area 150 to 175 sq. ft.) extending from the stoker to the mud drum of the boilers. The end walls give no trouble when carefully bonded to the facebrick of the setting. As an experiment, the front walls of one unit are to be built of fire brick shapes, supported by a cast iron or steel supporting frame. This construction will involve a sheet steel casing to make the setting air-tight, and will be less like a wall, and more like a steel casing protected from the fire by fire brick which are not self-supporting. In the last two units installed this autumn the walls are built with the surfaces slightly concaved on the fire side. The plan section is an arch, as shown by the detail drawing reproduced in Fig. 10.

Since each individual fire brick in a wall exposed to the fire on one side tends to expand permanently on the hot end, the tendency also is for each brick to pull in towards the fire. Bonding and anchor bolts ordinarily prevent this, but at some points, the influence of bonds and local anchoring is not enough to prevent large areas of the wall from falling toward the fire. The object of the "vertical arch" design referred to above is to wedge each individual brick into the wall by an arch construction and thus prevent the walls from bulging. The results, of course, remain to be seen.

Roney Stoker Settings. The most educative experience with brickwork has been had with the Roney stoker settings and their furnace arches. Starting

with two sprung arches under each mud drum with a central wall intersecting the bridge wall at right angles, the design ended up with a single continuous "flat arch," so called, under the mud drum, built of fire brick shapes hung from cast iron rail beams. (See Figs. 7, 8 and 11.) For these shapes a special brick had to be made of an exceedingly loose texture obtained by mixing sawdust with the clay before moulding. Upon burning in the kiln, this sawdust burned out, leaving the brick very porous. It was found that a harder, closer grained brick invariably spawled under the repeated heating and cooling to which it was subjected.

Limitations of Boilers as at Present Installed—Furnace Height. As at present installed, these boilers present certain limitations to being driven at any considerably higher per cent of rating than that already obtained. First, in burning West Virginia, long-flaming bituminous coal, it is probable that at, say, 275 per cent of rating and perhaps somewhat lower than that, the flames will reach the top of the combustion chamber, which is twenty-eight feet high. As soon as uncombined combustible gases get over into the superheater pass, the over-all efficiency of the unit will drop, for although secondary combustion will take place, nevertheless some unburned volatile matter must escape. Smoking will begin immediately after the secondary combustion becomes very considerable.

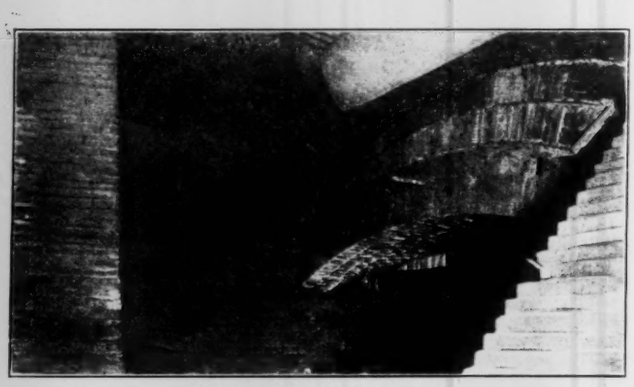


Fig. 11 Photograph of Arch for Roney Stoker

If the boiler in future installations is set much higher another difficulty will arise, although this is not so serious. Either more stack draft must be provided, or a pressure will be developed at the top of the combustion chamber, and the brick setting at this point must be built gas-tight. This phenomenon is readily explainable. Inside the combustion chamber is a column of gas like the column of gas in a stack. This stack is only 26 ft. high between draft gages in the present settings, but the gas column is at an average temperature of about 2300 deg. fahr. Figured statically this would create a draft of 0.3 in. of water at its base, providing the pressure at its top is atmospheric. However, if the maximum stack draft obtainable is reached at 250 per cent of rating with the present breeching and stack arrangement, the draft over the fire might become at 275 per cent of rating, only 0.1 in. As figured, this gas pressure over the fire must be less than at the top of the chamber by 0.3 in., neglecting friction. The pressure at the top would, therefore, become 0.2 in. above atmospheric. Pressure at this point is frequently developed in practice with the present settings.

Internal Losses of Pressure. Another limitation is the drop in pressure through the superheater, the automatic check valves and stop valve of the boiler. At 210 per cent of rating on one boiler, the drop in pressure through the superheater is 21 lb. which includes the pressure drop through the automatic check valves, but not that through the main stop valve. At 255 per cent of rating it would be considerably more. Since the pressure on the steam mains must remain constant, a pressure must be carried on the saturated steam drums of the boiler of 21 lb. more than at the superheater outlet, when running at 210 per cent of rating.

DISCUSSION

R. H. Danforth (written). The results of operation of this set of boilers, as reported by Mr. Parker, are no less startling than were the tests of the first three of these gigantic units, described by Dr. Jacobus in his unique paper.[1]

It is evident from Fig. 12, which shows a graphic comparison of the overall boiler efficiencies at different steaming rates, as obtained by Dr. Jacobus, with those shown in Fig. 4 of the present paper, that the extraordinary efficiencies obtained under test conditions have been not only maintained in service, but even improved by more than 1 per cent.

Of course this does not mean that boilers, like wine, improve with age. It can mean but one of two things in the present case, or perhaps a combination of the two; namely, a reduction in the temperature of the flue gases, or an improvement in the furnace efficiency.

Mr. Parker gives no data in his paper as to the losses in the flue gases, but if we refer to test No. 8, Table 16 of Dr. Jacobus' paper (the best test there reported, showing an overall boiler efficiency of 80.28 per cent at 108 per cent rating), we find that the flue gas temperature is 493 deg. fahr. and that of the steam at 200 lb. gauge is 388 deg. fahr., a difference of only 105 deg. fahr. This means that even if we could so improve this boiler as to discharge the gases to the stack at the same temperature as the boiler steam (assuming that the chimney draft thus provided would be sufficient to take away the gases), we could increase the overall efficiency of the unit by but slightly over 2 per cent.

Going again to Dr. Jacobus' paper, in the absence of sufficient information in Mr. Parker's, we find but 1.8 per cent of the available carbon lost in the ash, a very satisfactory showing for mechanical stoker operation, and one which we believe can hardly be bettered.

[1] Tests of Large Boilers at the Detroit Edison Company, Trans. Am. Soc. M. E., vol. 33, p. 565.

In Table 5 of Dr. Jacobus' paper, for Test No. 8 the CO in the flue gases was 0.02 per cent at the bottom of the last pass, 0.01 per cent at the top of the last pass, and 0.10 per cent in the flue. These discrepancies were discussed in connection with the presentation of the original paper, so we need not attempt to discover their cause. If, however, we assume even the highest of these values, 0.10 as the correct one, a completeness of combustion is indicated, which we can hardly hope to materially improve.

This test No. 8 of Dr. Jacobus' also shows a flue gas analysis which indicates a very moderate excess of air above that theoretically required to burn the coal, amounting to from 25 per cent to 40 per cent, depending upon the assumptions made as to the hydrogen in the coal and the steam-gas in the flue gases. It seems hardly credible that Mr. Parker has succeeded, with any form of stoker, in so improving the mixture of air and combustible gases in his furnace as to reduce this item of loss to any great extent.

I am unable to discover, from this analysis of the original tests on these boilers, any probable source of the improvement in their efficiency which he indicates, especially under operating conditions as against test conditions, even though the operating conditions are such ideal ones as Mr. Parker describes. I would like, therefore, to have Mr. Parker give us any data which are available, of flue temperatures, gas analyses, etc., which will indicate in what direction he has succeeded in making his gains, and obtained the marvelous operating efficiency which he reports. In so unusual a record of operation, Mr. Parker has set a mark quite as high, if not higher, than did Dr. Jacobus in their design.

Alex Dow said that the theory of the Detroit Edison management had been not merely to reduce floor space, to reduce the unit investment, and to secure a very high operating efficiency of the mechanism, but to demonstrate that in the boiler room, as in other departments, it was possible to pay larger daily or hourly rates to employees, and to get results that would warrant these rates.

Looking broadly at the proposition, the vital point had been the reduction of the number of firemen, and the education of those fewer firemen until they developed and demonstrated such interest in their work, as was evidenced by their insistence on checking their running instruments. A very much higher class of men could be obtained if the equipment were given them to show the interesting processes which they were carrying on. The firemen at the Detroit Edison plant were beginning to comprehend that they were carrying on exact chemical processes; that they had to watch not only the draft and the appearance of the fire, but also the CO_2 recorder. These firemen often went to the engineering department and asked for an Orsat apparatus to check up their recorders.

Ideals were not always realized and human nature had continually to be compromised with, but Mr. Dow felt that the approximation of daily practice to theoretically perfect working was much closer in the Detroit Edison Company's boiler plant, for the present year, than in any other plant in the country.

Albert A. Cary was interested to know what the experience had been, as far as checking was concerned, with the flow meters used in the Detroit Edison Company's plant. His experience had not been very satisfactory in that direction, and he wanted to know if the firemen had any other apparatus to fall back on in case the flow meters failed to give the proper records or not.

I. E. Moultrop said that in times past managers of plants took interest in their engine rooms, and let the firemen run the fire room. But in the fire room were to be found the greatest possibilities of economy in the operation of the power plant, and it should be in charge of the most intelligent men in the operating department. It was gratifying to see that the Detroit Edison Company was working along that line.

In answer to Mr. Cary, he said that he had had considerable experience with steam flow meters in Boston, and thought that they were quite accurate. As to the matter of checking, there was no instrument in the plant that was good for much if it was not periodically and systematically checked.

He had come to the conclusion that the CO_2 recorder was not so valuable an instrument as it had been assumed to

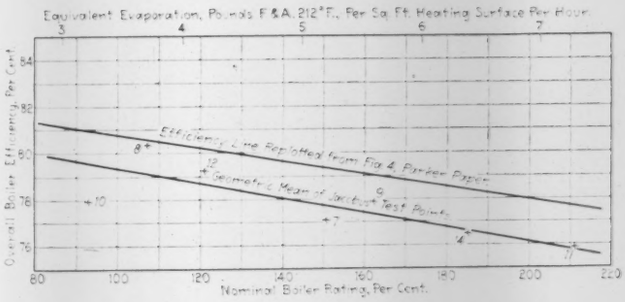


Fig. 12 Comparative Curves showing Relation between Results reported by Mr. Parker and those obtained in Dr. Jacobus' Tests on the Same Boilers

be in the past. With feedwater regulators and steam flow meters, and with the intelligent help in the fire rooms of today, the CO_2 recorder was one of the least valuable instruments on the control board. Mr. Moultrop did not mean, however, to condemn the instrument as a piece of boiler room apparatus. He believed it was a more delicate instrument than others and required more attention to keep it in satisfactory working condition. It had one disadvantage: the other instruments mentioned showed what was taking place in the operating of the boiler, whereas the CO_2 recorder told what had happened sometime previous, the lag being somewhere between 5 and 20 minutes' duration. The fireman was not especially interested in post mortems; moreover, an intelligent fireman would find ways of getting satisfactory CO_2 readings on his recorder without necessarily getting ideal conditions in his furnaces.

George B. Preston had found that one of the principal difficulties in starting up large boilers was in connection with the fire brick lining and the combustible arches, and he wished to ask what material Mr. Parker found to be the best, and if he had any illustrations showing the failure of these brick arches.

Roger DeWolf asked what connections there were, if any, between the blower supplying the air to the stoker and the drive for supplying the coal. He also wished to know if Mr. Parker would consider a semi-automatic control for the blower, at least as being a desirable proposition. A

new equipment of 875-h.p. boilers was being installed in Rochester using a semi-automatic control on the blower and a motor-driven feed for the coal, which was entirely in the hands of the firemen for operating.

Mr. DeWolf agreed with Mr. Moultrop regarding the use of CO_2 recording meters, but would like to have further details. In the above installation it was being arranged to measure the feedwater continuously in order to get continuous records of the feedwater and of the amount of coal burned, and it was expected to rely on these, together with steam flow meters on the boilers, rather than on any CO_2 determinations.

William Kent (written). The CO_2 recorder is a necessary evil; it must be used if the best economy is to be maintained. There is no record of tests that I know of (where several tests in succession gave high efficiency) published either in this country or in England, where the CO_2 meter, or the Orsat, or the Hempel apparatus for determining the CO_2 was not used. I have in mind an apparatus using oxygen instead of carbonic acid gas. The maximum efficiency is coincident with 3 to 7 per cent of oxygen in the chimney gases, and if there is 5 per cent of oxygen in the

Fig. 13 Cross-Section of Tube, and Outside of Tube showing Leak

chimney gases it is as nearly right as it can be. With the CO_2 meter on the other hand, if there is 15 per cent of CO_2 the economy might be high or it might not, because 15 per cent CO_2 means the possibility of a good deal of CO in the gas.

The control of the boilers, as described in the paper, so as to obtain the maximum efficiency, is effected by two things acting together: First, the disappearance of the flame at the top of the combustion chamber, which shows that the combustion of available gas is entirely complete (wherever there is a visible flame there is imperfect combustion; that is, the flame must extinguish itself by burning out so that the combustion is entirely complete to insure that the operation is smokeless). Second, the CO_2 should be about 13.5 to 14. The two things are necessarily taken together: If there is smokeless combustion there may be maximum economy, but on the other hand there may be poor economy on account of a possible great excess of air. In order to avoid the error of a great excess of air, therefore, the CO_2 apparatus must be used.

Reginald P. Bolton said that these boilers were a wonderful exhibition of what might be expected in the future construction of boilers intelligently designed to give the gases a chance to burn themselves out, giving complete combustion before the gases got out of the boiler. Another lesson to be learned from these boilers was the effect which such large power uses had in improving the morale and the conditions of the working forces.

As to the meffectiveness of the CO_2 recorder, Mr. Bolton was inclined to think that much of the troubles arose from the difficulty of collecting the sample. He had just come from a series of observations conducted on large stacks of the Waterside station of the New York Edison Company, during which a great variety of samples covering a long period of time were gathered from the smokestacks 200 and 300 ft. in height. From a selected point in the stack it was found, after a series of experiments, that the velocities varied all over the stack, that the contents of the stack varied, and in one case, after the medium point had been established by a series of experiments, the current of gases reversed itself in the stack at that point, and there was actually a down-flow instead of an up-flow. It might be well therefore that the poor CO_2 recorder as a gage becomes mixed up from time to time. A great deal of study had yet to be made of the flow of gases in flues and smokestacks.

D. S. Jacobus said that careful gas analyses were made in his tests and had not the CO been carefully measured as well as the CO_2 it would not have been possible to attain the high efficiencies. The presence or absence of CO was most important. If in operating a furnace it was found that there were certain indications respecting the length of the flames, or the like, that gave a line on the amount of excess air and the presence or absence of CO in the gases, a furnace could be operated just as well by observing these manifestations as by making gas analyses. Indications of the sort were highly valuable in serving as a guide for securing good combustion. In Mr. Parker's tests both means were employed and contributed to the attainment of the high efficiencies.

Dr. Jacobus complimented Mr. Dow on the progress he was making in putting the right sort of men in the boiler room. He said there was more to be gained or lost in a boiler room than in any other part of a power plant, and he predicted that eventually it would be common practice to place the boiler room in the direct charge of the best men in the organization.

David Moffat Myers said that he had found a very bad state of affairs in the fire rooms of factory power plants. The management, as a rule, had not the slightest understanding of what was going on. There was usually not the best of feeling between the chief and the firemen, and this was the first thing to be readjusted by the education, not alone of the firemen, but of the management. Mr. Myers had in mind a typical small factory plant which had been drifting along for a good many years in the belief that no improvement could be made. A test showed that two boilers were being fired at only half their capacity, although on certain days they were not holding steam because, as the engineer said, the draft was too weak. They were evaporating 6 lb. of water per 1 lb. of fuel. That plant was greatly improved without spending any money on equipment, by educating the firemen to fire properly. Only one boiler was now being fired and with the damper closed one-third of the time to prevent steam from blowing off. One pound of fuel was evaporating 8.5 to 9 lb. of water instead of 6 lb. as formerly, and the fireman of the plant was delighted. He had been educated by practical example, was

getting more money for his services and was intensely interested in his work. The management had their eyes opened and were tremendously interested and satisfied with the results. They were making over 40 per cent more steam for the same consumption of fuel and without a dollar spent for new equipment.

The preventable losses that today existed in factory power plants were tremendous. These losses were chargeable fully as much to lack of education as to improper equipment, and the management was directly responsible for both of these factors.

For some reason it was a fact that owners would go to great expense for producing efficiency in other departments of their business while they allowed their power and heating plants to get along in the most haphazard way. A reform of education in this direction would enable the payment of wages to firemen properly commensurate to their responsibility and would at the same time largely increase the net profits of the owner's business.

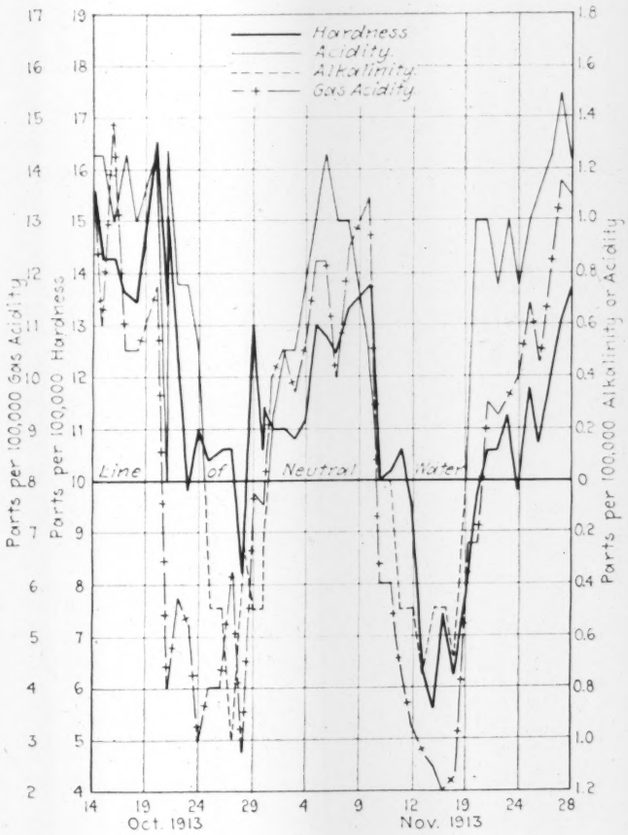


Fig. 14 Analyses of Water from Monongahela River at Rankin, Pittsburgh

Such a reform was gradually taking place, and it was bound to succeed universally for it combined at the same time the principles of science and of humanity.

Harrington Emerson, while praising the detailed information given in the paper, objected to the inclusion of violently varying maintenance or supervising costs as pertinent. There were standards for maintenance costs as well as for power costs, for supervision and for rent, and standard allowances should be used in determining final costs, not accidental variations. In the report criticized, one of the boilers cost in one month for maintenance labor and material $1.71, another cost $253.02. When such great accidental variations occur the conclusions as to cost of product which include them are vitiated.

Railroads can rightly assume a repair cost of $0.08 a mile for repairs (if this is the average), but no railroad can properly include in the cost of a single trip the destruction of a locomotive by explosion, nor yet omit the item of repairs from the cost of a particular run. In all cost accounting reference to standards is needed.

Albert A. Straub (written). Although Mr. Parker has shown by results obtained in three and a half years of operation, that the operation of so large a steam generating unit is not only feasible, but highly satisfactory, from the most important points of operation and maintenance, it seems, nevertheless, that the choice of such a unit must be governed largely by local operating conditions.

Fig. 15 View of Arch in Sagged Condition Five Days before Part of It fell

Mr. Parker stated that a scale of $^1/_{16}$ in. thickness would form in the hot front tubes, but did not state how long it took to form this scale. I judge it was formed between the periods of turbining tubes, but would desire further information on this phase of the subject. That mud will cause leaky tubes not only with $^1/_{16}$ in. or heavier scale, but with scale of egg-shell thickness, and not only at high but at moderate rates of driving is evident, as shown by Fig. 13. These photographs are of a tube taken from the lower row of tubes of a 375-h.p. Babcock and Wilcox boiler equipped with Roney stokers and having a small combustion chamber. The damaged portion of the tube was exposed directly to the action of the flame. The feedwater was taken from the Allegheny River and contained from six to ten parts per 100,000 of incrusting solids, being treated with enough barium hydrate to neutralize the sulphate content. The tube was a 4-in. No. 10 gage, lap-welded, charcoal iron tube, so placed that the weld was not exposed to the action of the flame. The photographs of this tube show that the leak occurred directly under the deposit of mud and that the scale was so thin as to have practically no effect. Observations made at other times on tubes which were renewed at this station showed mud to be the cause of overheating. The boilers at this station operate usually at rating and, for short periods, at as high as 75 per cent above rating. The question of the behavior of such a sized unit when using bad water is of vital importance to engineers of the Pittsburgh district. I have plotted (Fig. 14) 44 analyses of water from the Monongahela River taken at Rankin,

Pittsburgh, Pa., from October 14 to November 29, inclusive. Thirty-two of these analyses showed the water to be either neutral or acid as high as 1.50 parts per 100,000. Such a water as this cannot be fed to a boiler untreated and a surface condenser with such a water should not be considered.

With water of this character it has been found that cast iron will be eaten out in anywhere from two to six months, and it is a question what will happen to the tubes of a surface condenser. When using the jet condenser and treating the feedwater in a softener before it enters the boilers a large quantity of sodium salts is fed into the boiler. If the water is treated as it enters the boiler, without a softener, it has been found that a very slight concentration of sodium salts will cause the water to become wild and hard to keep in the front tubes of this type of boiler, at moderate rates of driving.

Fig. 16 View showing Arch after Part of it fell. Fallen Part patched

Mr. Parker stated that he treated the make-up water with barium hydrate, but did not state where he added it, or whether he filtered the water after it was treated. I have had the best success with this treatment if I could remove the precipitated salts in some manner before the water entered the boiler.

I note no reference to any instrument for recording temperature of escaping gases. This record and that of a recording draft gage are of vital importance, especially during periods of banked fires, where the overfeed stoker is in use.

Considerable stress seems to be placed upon having the proper CO_2 content in the gases of combustion, which no doubt is deserving of commendation. My experience has been that it is also advisable to insist upon a low combustible content in the refuse from the ashpit or there is a saving of the one at the expense of the other. Mr. Parker seems to have neglected entirely any reference to the quality of refuse from the ashpit. I should like to know if he maintains any record of this factor.

In regard to arches on Roney stokers Mr. Parker does not give any data obtained from his experience with sprung arches. Figs. 15, 16 and 17 are views of a sprung arch, which together with a history of this arch, may prove of interest.

The photographs are of an arch of one of a battery of two 375-h.p. Babcock and Wilcox boilers, Alert type of setting with Roney stokers having a grate area of 92.5 sq. ft. each. The arch is 11 ft. span, 6 ft. 4 in. long and has a spring of 16 in. The furnace temperatures observed with a Wanner pyrometer through a peep hole 1 ft. below the edge and 1 ft. from the front of the arch, when this furnace was in operation, varied from 2800 deg. to 3000 deg. fahr. This arch was made of Woodland brick and was placed in operation December 12, 1910. On April 18, 1911, the arch was in the condition shown by Fig. 15 (badly sagged), the boiler having been off for leaky tubes or general cleaning nine times in this period of four months and six days. The boiler was placed back on the line in this condition and operated until April 23, 1911, when part of the arch fell, as is shown by Fig. 16. This defect was patched and the boiler placed back on the line May 4, and operated without shutdown until June 25, when the whole arch fell, as is shown by Fig. 17. The short life of the arch was due to faulty side walls. The arches and side walls in both boilers were then rebuilt and held from August 1, 1911, to October 29, 1912; during this period the boiler was off 15 times either for leaky tubes or general cleaning.

The Author. As far as the fireman is concerned, the steam flow meter need give merely relative indications for his guidance. Extreme accuracy is not necessary for his purpose nor would a constant multiplying error mislead him seriously. The experience at the Delray plant has been, however, that, properly installed and calibrated, the flow meter is reliable and use is being made of it for *absolute* measurements of steam also.

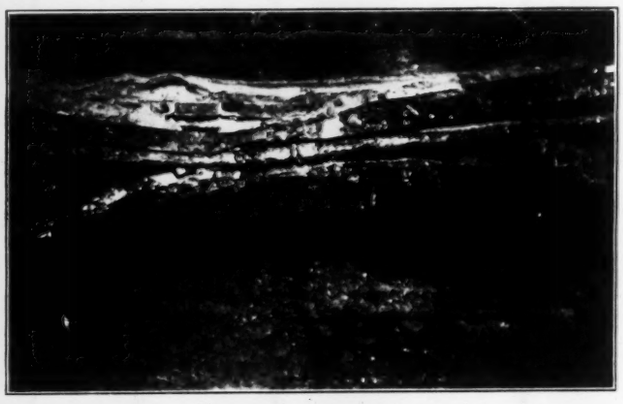


Fig. 17 View showing Arch after it fell completely

It should be understood that the curve (Fig. 4) of overall efficiencies obtainable with the underfeed stoker, is a straight line drawn through points taken from the Jacobus tests. The actual efficiencies attained at the extreme points of the range of the tests are given in the paragraph on Flexibility in the present paper. The curve of efficiencies presented by Dr. Jacobus in his report of the tests, was intended to show the characteristics of the boiler as fired by either the underfeed or natural draft stokers. The latter tended to give slightly better results at low ratings and lower efficiencies at very high ratings, than did the underfeed stoker.

The efficiency curve of the present paper has been set up as an ideal for which to work in daily operation. The instruments on the gage board were chosen to give the fireman as much information as possible to aid him in approximating such maximum efficiencies. During a test he has other information continually at hand. Most important is the apparent evaporation, figured cumulatively from the start of the test. However, apparent evaporation is but a derived result and does not show the fireman the causes which lead to it. For judging of present conditions, it is

invaluable for him to know drafts at various points of the furnace, rate of steaming as shown by the flow meter and the record of CO_2 in the flue gases coupled with observation of the gases entering the superheater. It has been asked why use is not made in this connection of pyrometer readings of the temperature of the exit flue gases. This has been attempted, but for everyday work this exit temperature was found to be dependent upon too many other variables whose influence on it is not well enough known. During a certain test, when the rate of steaming was being held practically constant and the combustion of volatile gases was known by inspection to be very complete, the temperature of the exit gases was found to be extremely valuable in showing up an excess of air. The temperature invariably rose when the gases contained too much air and fell as the excess was decreased. It was possible in this way to predict changes on the CO_2 recorder chart, since the recorder readings lagged at least 5 minutes behind the flue gas conditions. In spite of this experience, it was decided to omit exit gas pyrometers from the list of necessary operating instruments.

The almost complete combustion which was obtained during Dr. Jacobus' tests is not too difficult to obtain every day. Flue gas analyses show almost daily as good or better furnace conditions for hours at a time. While driving these boilers at above 200 per cent of rating, and in one case at about 225 per cent of rating, the gas analyses by recorder and Orsat apparatus and inspection of the gases entering the superheater showed better combustion than that secured while running at equally high ratings during the tests. It is only natural that the firemen should become more skilled than they were three years ago. Again, with the self-cleaning stoker installed with one of the latest of the boilers, routine sampling of the ash during December of 1913 showed an average of 12.6 per cent of combustible in the ash, there being 10.2 per cent of ash in the air-dried coal.

In the discussion, further questions were asked in regard to automatic or semi-automatic control of the air supply to the stoker. Before adopting such automatic control, there is this point to be considered. The load of the plant is varying up and down 1 or 2 per cent continually, the greater variations being as a rule more gradual or else periodic. This is, of course, not considering such sudden peaks as those occasioned by thunderstorms. This sawing up and down of the load will occasion slight variations of steam pressure and this allows our taking advantage of the capacity of the boilers for heat storage in the water. It is not necessary that the rate of fuel combustion be so often changed. It would be a mistake to employ an air supply controller which would attempt to hold constant steam pressure, if in so doing it were continually to disturb the rate of combustion of the fuel.

In regard to the paragraph of the paper on maintenance costs, it was intended to show the cost of material and labor required for repairing these two units during a period immediately following the season of peak loads, when time was afforded for repairs which might have been difficult to accomplish when load conditions were more severe. Since the plant contains various types of boiler and stoker equipment, it was not desired to use for the above purpose, the average boiler, stoker and furnace maintenance costs for the whole plant, which could have been obtained from the plant operating accounts.

TASK SETTING FOR FIREMEN AND MAINTAINING HIGH EFFICIENCY IN BOILER PLANTS

By Walter N. Polakov, Philadelphia, Pa.

Member of the Society

ABSTRACT OF PAPER[1]

The determination of the practical maximum economy of boiler room operation is the subject of this discussion. The question is twofold in its nature: (*a*) how to obtain this maximum economy of operation, and (*b*) how to secure the permanency of the results attained. The first part of the question involves the theoretical research into the problem which embraces: (*a*) analysis of variables, (*b*) limiting influence of variables on maximum, and (*c*) dependence of results from time rate. This part deals with methods of experimental determination of maximum theoretical efficiency obtainable under given conditions, and incidentally refers to the graphical method of study of boiler trials as applied to actual examples of the writer's tests.

The well-known falling short of test results in everyday performances forms the connecting link with the second part of the paper, and it is shown how the results of theoretical research can be made practically obtainable in regular service. This embraces the methods employed by the writer in studying the psychophysiological element of the problem. In order that the prescribed conditions be maintained and the desired results of high economy of operation be accomplished, not spasmodically, but day in and day out, the task put before men ought to be (*a*) possible, and (*b*) desirable.

The possibility of accomplishment of task is governed by (*a*) proper coördination of conditions and supplies with power demand and existing facilities; (*b*) proper guidance of men in their work; (*c*) proper balance of strain during the work and regain of physical losses of the individual during intervals between working periods. Part (*c*) complements the common method of time studies, with a new method of physical studies of the effect of work on the health of workingmen and a method of scientific determination of length of working day.

The desirability of accomplishment of a task set within men's possibilities requires the study of: (*a*) physical stimuli, (*b*) psychical stimuli, and (*c*) social stimuli. To the group (*a*) is referred payment of bonus, better surroundings, shorter hours, sanitary conditions, etc. To the group (*b*) factors like sporting

[1] Published in complete form in the December 1913 issue of The Journal of The American Society of Mechanical Engineers. Pamphlet copies can be obtained for 15 cents to members and 30 cents to non-members.

spirit, confidence in records, relationship with management, desire to study and advance, etc., are referred. To the last group (*c*) belong such stimuli (favorable or not) as attitude of fellow workmen, of trade unions and socialist party, of members of the family, and condition of labor market, legal regulations, etc. To the above plan are added examples of records from practice, and description of methods greatly simplifying the working out of records and logs.

DISCUSSION

William Kent said he was pleased with the papers by Mr. Parker and Mr. Polakov because they went largely into the question of the human element in the boiler room. In the first paper the human element seemed to have been dispensed with as far as possible and automatic machinery substituted in its place, and secondly, in the case of those firemen that could not be dispensed with, very high wages were paid. This was an important step forward.

Mr. Kent knew of no other paper that treated so exhaustively of the human element in the boiler room as did Mr. Polakov's, and he congratulated him on his earnest efforts in that direction. In regard to the mathematical portion of the paper, he did not think Mr. Polakov had treated the subject in the right way: he had gone far into the mathematical treatment, but it did not appear that he obtained any results that were of practical value.

D. S. Jacobus believed it impossible to get up an equitable bonus system where the men in the boiler room would be paid individual bonuses. The whole organization should be taken together. If an endeavor were made to pay individual bonuses, based on the boiler efficiency secured in each case, the men would soon find out that by carrying a uniform fire they would get the best efficiency. In the case of a fluctuating load those conscientious enough to meet the variations by manipulating the fires to give more or less steam would be penalized through their inability to run at as high a rating as the men carrying uniform fires. It was hard to see how this point could be covered in any equitable system other than by considering the work of the men as a whole.

He considered that the best way of handling the situation would be to put the right sort of a man in charge in the boiler room and make him responsible for the results, in which case the men might be given an increase in pay in proportion to the amount they could save by exerting themselves to the utmost. The general idea that the firemen were opposed to improvements did not seem correct to Dr. Jacobus. He had had considerable experience in working in fire rooms to get the best out of the men and knew that if the firemen felt that the expert was in a certain sense one of them, they would do all that they could to coöperate.

Dr. Jacobus agreed with Mr. Kent that the method outlined in the appendix of determining what a boiler should do was quite incomplete. For example, there was apparently nothing to connect the baffle arrangement with the efficiency. By changing the baffle in a given boiler the heat transfer rate would be altered, say, 50 to 100 per cent, and it seemed there was nothing in the method outlined by Mr. Polakov to cover this.

H. G. Stott took exception to the curves showing the most economic loadings for various types of boilers. His experience was that the type of boiler had very little to do with that question; it was entirely a question of the furnace and the combustion of the fuel. A boiler could be driven easily up to 400 per cent rating, or even more. The arrangement of the tubes one way or another was immaterial.

In the table of the rate of boiler readings, No. 7, a firetube boiler with superheater, was given as the most economical one. Mr. Stott said he had efficiencies on the regular Babcock and Wilcox boiler equal to those shown in this curve; the Babcock and Wilcox boiler could be carried practically to unlimited rating. Inseparable from this question of rating was one of the economics of the plant. A plant might be run at an efficiency of 60 per cent during the peak load, and operate more economically, when the fixed charges were taken into consideration, than when running at 80 per cent. When running at 80 per cent, the boilers had to be operated at 70 per cent of the so-called rating, and above that these high efficiencies were not obtainable. At the same time, if two curves were plotted, one of the fixed charges per kilowatt-hour, and the other of the operating cost per kilowatt-hour, it would be found that for the peak load which might last two or four hours a day, the operating charges were relatively unimportant, but the greatest care must be taken to keep down the fixed charges. In other words, the number of boilers on a line must be kept down, as well as the number of banked boilers to be operated.

Mr. Stott believed the time was coming when a boiler plant would be equipped with modern combustion appliances, otherwise modern stokers, which were practically automatic and required little attention. Not firemen, but combustion engineers, or men who had graduated from technical schools, would be required then. It was impossible to get that type of man to go into the boiler room yet, but this would come about when owners of boiler plants were willing to pay more to the man who operated the boiler than to the man who operated the turbine room or the engine room, because the latter could make no change in the economy of the plant, whereas the former could make 5 to 10 per cent difference.

Albert A. Cary (written). The skill of the firemen and the ability or capacity of those who have them under their charge are most important factors in the economical operation of a boiler plant and means must be employed, during preliminary investigation work, to ascertain the part played by such men in arriving at the results obtained. Special apparatus should be used to determine carefully every individual feature included in the furnace, boiler or other part of the equipment and every variable condition which enters into the operation of the plant should be noted at the time it actually occurs. Merely taking observations during the time of a test and waiting until after its conclusion to work up all results, and then attempting to make deductions is a practice which will often lead to the overlooking of very important occurrences which would lead to a materially different method of future operation of the plant.

I have found it extremely desirable to use a system in testing by which very frequent gas analyses are obtained (not less than from six to eight per hour) and these results are chalked up on a blackboard as rapidly as they are ob-

tained. By this means it is possible to follow closely the occurrences taking place in the furnace during the course of a test. When making hand-fired tests, I use a device which tells exactly the number of seconds the furnace doors are kept open. Together, these two means serve to size up the value of a fireman very quickly and the comparative merits of two alternate firemen become very apparent in a short period of time. This subject was treated at considerable length by me in a series of papers[1] written for the Iron Age.

It is to be hoped that Mr. Polakov will make his mathematical discussion of this subject a little clearer in revising this paper. The value obtained by using such a method as described by him is, however, governed by the correctness of the observations obtained during test, and as these test results are so commonly in error, the general use of such an analysis may prove unsatisfactory. It may prove desirable to use this graphical method in some one plant where the repeated errors may be fairly constant, and under such assumed conditions, introduced improvements will doubtlessly be made apparent.

I have had considerable experience with Segar cones for determining furnace temperatures and have found that the true furnace temperature could not be obtained through their use on a poker, as was shown by Mr. Polakov. I have found their general use so unsatisfactory that I have abandoned them entirely. The proper use of a good optical pyrometer will give the most reliable results.

Referring to the statement as to the unpracticability of getting a gas analysis every three minutes, I have not only obtained the ordinary gas analysis (including CO_2; O; CO and N) for 3 minute intervals, but have also succeeded in obtaining the complete analysis of the gas including H and CH_4 over 3 minute intervals. But generally, in refined boiler testing, intervals between analyses should not be over 10 minutes.

Mr. Polakov states that the weight of the steam generated is in direct proportion to the weight of fuel burned. I hardly think that he intends this statement to cover operation below rating, at rating and when the boiler is being greatly forced. Also he speaks of having the firemen carry the fire bed at a uniform thickness; this is hardly practical in hand-fired practice where, after cleaning, a comparatively thin bed is started which is increased in thickness up to the time of the next cleaning, although the use of good shaking grate bars will remedy this condition somewhat.

Mr. Polakov showed a large number of factors used to arrive at the useful result obtained in steam generation, but these only serve to complicate and obscure a rational consideration of the problem. I make it a practice to determine the individual efficiency of the furnace, and study my furnace conditions apart from the balance of the combination. I then determine the individual efficiency of the boiler and study it by itself, and find whether the boiler is operating under improper furnace or other conditions.

Unfortunately, boiler efficiency is not a fixed quantity under varying conditions of operation, depending largely, as it does, upon the operation of the furnace; with no fire in the furnace, the boiler has no efficiency at all. But, during the course of any particular test, the boiler has its individual efficiency for the set of conditions found at that time, and the study of its efficiency in connection with its controlling conditions shows us where we can improve the defects under which it is operating. These, if remedied, will raise the efficiency of the entire steam generating unit.

The efficiency of the boiler has long been considered and obscured in the reports of *combined* boiler and furnace efficiency, as this combined efficiency is composed of the product of the furnace and boiler efficiencies. When a low combined efficiency results during a test, how are we to know whether the fault is in the boiler or in the furnace? Inference may help us somewhat, aided by the observations taken, but this old time "cut and try" method of making improvements is not in keeping with modern engineering efficiency practice.

R. J. S. Pigott, referring to the diagram showing most economic loadings for various types of boilers, thought there was still a good deal of misapprehension among most engineers as to the economic point of loading both of a boiler and of a turbine. He found that the efficiency of the boiler and of the turbine had much the same characteristic, namely, there was a dome or high point at some place in the load: with the turbine it was usually at full load that the best efficiency occurred; beyond that point there might be some 25 or 50 per cent capacity allowed for overload. In the boiler this best loading occurred very low in the total capacity of the boiler, about one-third or one-quarter of the maximum capacity. The total rating of the engine room consisted not only of the usual rating of the turbine, but also of the auxiliaries necessary to run the turbine; in other words, the water rate of the turbine might be 12 or 13 lb. per kw. at its best load, but when the load required to drive the auxiliaries was superimposed, the water rate was much higher, possibly 16 to 18 lb., and the best water rate, including the auxiliaries, was always at a higher load than the best load on the turbine only. This was also true of the boiler room, the auxiliaries required in this case, the forced draft fans and possibly induced draft fans, the boiler feed pumps, etc.

While the condenser auxiliaries ran with a practically constant amount of steam, no matter what the load on the turbine, the units in the boiler room were different and required somewhat less steam at lighter loads than at full load. For instance, with a centrifugal boiler feed pump the total steam consumption at zero delivery was seldom less than 55 per cent of the steam at full load on the pump.

If the net output of steam per boiler delivered by the boiler room were considered, the most efficient point would always be at a higher load on the boiler than the best efficiency of the boiler alone.

Edw. A. Uehling (written). Mr. Polakov's paper brings out two very important points: First, it emphasizes the fact that the boiler house is the place where the greatest savings can be made, and second, that boiler efficiency tests are of very little economic value unless adequate means for guidance and control are inaugurated, and due consideration is given to the human element.

The economic conditions found in the plant under consideration in Mr. Polakov's paper are those prevailing in the majority of steam boiler plants. The fact that a "saving of approximately 25 per cent on the fuel bill alone was

[1] Iron Age, Vol. 90, p. 832 ; 900 ; 1012 ; 1026

accomplished without heavy capital investment" for equipment and alteration of plant, etc., except for the necessary apparatus and instruments for control and guidance of the boiler room crew, should serve to arouse all those power plant managers who have given the question of fuel economy insufficient thought, or have attacked the problem only in a more or less superficial way. It is still insufficiently realized that maximum fuel economy cannot be maintained where the personnel of the boiler room are compelled to work without means to guide them in the performance of their task and without incentive to improve their efficiency.

As to the necessity of keeping the fireman informed how well he is, or has been, performing his task, there can be no question; as to the best method of accomplishing this end, opinions may differ. Mr. Polakov presents a very complete bonus system which is no doubt effective, and the principal cause of maintaining the high efficiency reported, but it is too elaborate to merit wide application. I would also question the rationale of his guide to efficient firing controlled entirely by the steam flow meter indicating the thickness of fire and draft to be maintained; there is no constant relation between draft and thickness of fire. The effectiveness of a given draft is modified by several factors: (*a*) the conditions of the fire as affected by the size of the coal, which may vary greatly from hour to hour, (*b*) the thickness of the ash bed, and (*c*) the presence of clinkers. Thus 0.6 in. of draft may be less effective when the fire is dirty than 0.4 in. after it has been cleaned. Mr. Polakov does not say whether all the boilers are controlled by one flow meter on the main steam line, or whether every boiler is equipped with an individual flow meter. In the former case, how can a fireman tell whether *his* boiler is making its full share of the steam required? In the latter case, the less an individual boiler does, the less the indicator will show what it ought to do. It would seem, therefore, that a guide to the fireman controlled by a steam flow meter would be of questionable value. The success which Mr. Polakov scored in attaining and maintaining the high efficiency is due:

a To putting the plant in the best possible condition and selecting the most profitable kind of coal;

b To thoroughly instructing the personnel of the boiler house and providing for their legitimate comforts;

c To the inauguration of a liberal bonus system, based on the actual efficiency of every individual fireman, and

d To the most admirable system of investigating every shortcoming as to its reason, in order to determine whether it was due to the man, or to something over which he had no control, and if the latter, to at once remedy the cause.

The fact that in order to carry out the above plan, it is necessary to correctly meter the water to every individual boiler, to keep tabs on the water wasted in blowing off and that fed to boilers banked, and to weigh out the coal for every individual fireman for each shift; also to make the necessary calculations and write out the individual reports, etc., necessarily brings up the question whether equally good results may not be obtained by simpler means.

Mr. Polakov mentioned several other ways in which it has been attempted to inaugurate bonus systems for firemen, all of which he doomed to failure. Among others he mentions the attempt to base such a bonus system on the percentage of CO_2 contained in the flue gas. Of this, he says, "The high percentage of CO_2 in the flue gas was adopted as a task basis for firemen in several plants, but the men were not trained nor were they shown how to obtain it. When they occasionally attained the mark, the question remained undecided whether the high percentage of carbon dioxide was coincident with the most economical steam generation or not, and the method proved generally unsatisfactory."

I ask the question: How could it be otherwise? Would not Mr. Polakov's system prove worthless if carried out in the same slovenly way? It can be safely stated that wherever CO_2 has failed to be a true guide to efficient firing, it has been due to similar causes.

It is an indisputable fact that of any given boiler fired with the same fuel under the same conditions, the higher the percentage of CO_2 within the limits of practically complete combustion, the higher will be the efficiency. Any exceptions that may have been noted are always due to variations in the fuel, either physical or chemical or both, type of boiler, type of furnace, rate of driving, etc., etc.

For example, excessive stack temperature due to hard driving, or insufficient heating surface, or a dirty boiler, may easily neutralize the benefit due to several per cent of CO_2, and thus it may, and does frequently happen, that the same boiler driven more moderately, resulting in a low stack temperature, may show a higher efficiency with a lower percentage of CO_2 in the products of combustion. When the results from boilers of different types operating under quite different conditions are compared, the apparent contradiction to the above statement may appear even more obvious. None the less the fact remains, that in every case where a comparatively low efficiency is obtained with the high percentage of CO_2 it would have been still lower if the CO_2 had been lower, and where a comparatively high efficiency results from a lower percentage of CO_2 it would be correspondingly higher if the CO_2 had been higher, and these apparent contradictions do not all militate against the value of CO_2 as a guide for, as well as a control, over the fireman. Wherever exceptionally high boiler efficiency has been achieved and maintained, a high percentage of CO_2 in the flue gas has been obtained and maintained.

The high standard set by Dr. Jacobus by the efficiency tests of the large boilers at the Delray Plant of the Detroit Edison Company was achieved with a percentage of CO_2 averaging over 14 per cent, and this high standard of efficiency has been practically maintained under every day working conditions, using the continuous recording and indicating CO_2 meter as the principal guide for the firemen, as reported in Mr. Parker's paper.

That this cannot be otherwise becomes self-evident, when we take into consideration the fact that up to 90 per cent and more of the heat loss in the generation of steam in the average boiler, passes up the chimney, and that the heat loss is the product of weight of the products of combustion, the temperature at which they escape multiplied by the specific heat, and that the weight increases rapidly as the CO_2 decreases and that the temperature is not materially changed, due to the percentage of CO_2 in the flue gas. The above statements are fully verified by the figures given by Mr. Polakov in Appendix No. 3.

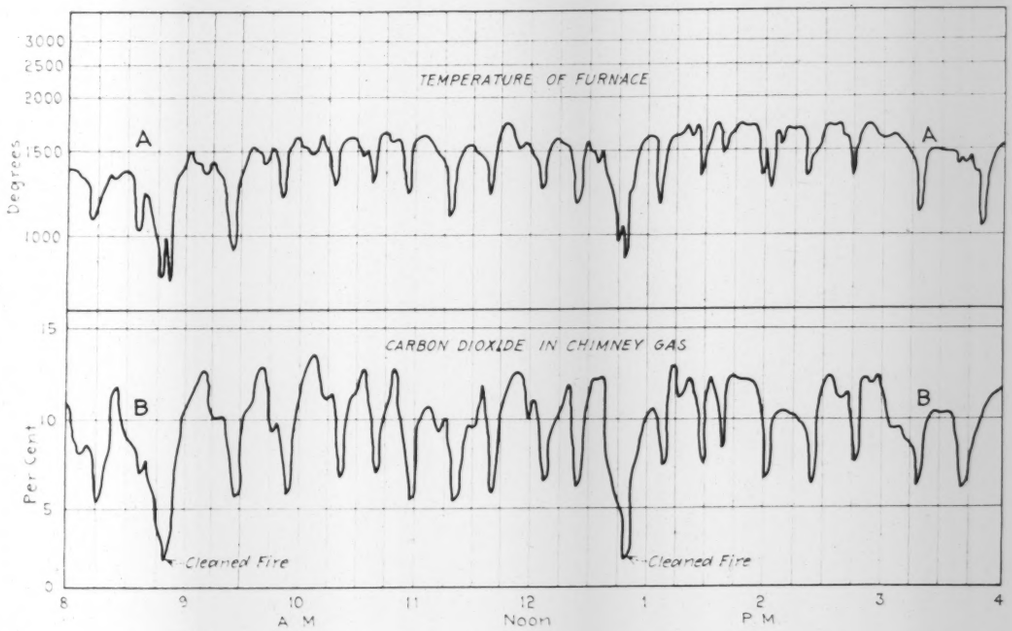
Much stress is laid on the danger of losing more by the presence of CO in fuel value due to high CO_2, than is gained

in reducing the loss of sensible heat by reducing the weight of the flue gas. While I, by no means, wish to under-rate the importance of complete combustion, I do believe that there is much misconception regarding this point. In a paper,[1] Combustion and Boiler Efficiency, read before the Society three years ago, I believe to have demonstrated by some 1100 odd flue gas analyses that there is no relation between the content of CO and CO_2 in flue gas; that low CO_2 is no guarantee that combustion is complete and high CO_2 is not necessarily accompanied by an appreciable percentage of CO. This fact is also borne out by the flue gas analyses reported by Mr. Polakov, which showed that the lowest percentage of CO_2 was accompanied by the highest percentage of combustible gases. Complete combustion depends much less on a large percentage of free oxygen than on the method of firing and the construction of the furnace, and most of all on the furnace temperature, and inasmuch as an unnecessary amount of excess air lowers the furnace temperature, very low CO_2 is more likely to be accompanied by combustible gases than rationally high CO_2.

It has been abundantly demonstrated that with correct furnace construction, thorough instruction and proper treatment of the firemen, and by providing them with adequate means for their guidance and control, 12 to 15 per cent of CO_2 can be regularly attained without appreciable amounts of CO and maximum efficiency thereby maintained. It has also been demonstrated that a large excess of air, i. e., a low percentage of CO_2, is no guarantee against incomplete combustion, that sporadic boiler tests and occasional gas analyses are of little value, that half-hearted attempts with an inadequate means for guidance and control cannot succeed and are therefore a waste of time and money.

To insure success the conditions must be studied, radical defects must be remedied, the firemen must be instructed and their legitimate comforts considered, an incentive to excel must be given, and above all, adequate means for their guidance and control must be provided. The correctness of the above general proposition will be conceded by all who have given the question of boiler house economy due consideration.

Dr. Kent made the statement, "If we could get a continuous record of the furnace temperature, we should have no need of CO_2 recorders." This statement is apparently corroborated by the fac-simile of two records shown herewith, which were made simultaneously by a combined Uehling CO_2 meter and pyrometer. The gas analyzed was drawn continuously from a Babcock & Wilcox boiler near the uptake, and the temperature was taken a few feet back of the bridge wall. These two records corroborate one another to a remarkable degree, and that one could apparently serve as well as the other as a guide and control of combustion efficiency. It will be noted, however, that CO_2 gives the more pronounced record. The temperature is also less valuable than the CO_2 because it is not a direct factor in determining the loss up the chimney; it is also unreliable, in that it is impossible to distinguish whether the variations in temperature shown by such a record are due to irregular driving or irregular air supply. But such determinations are impracticable because there is no pyrometer available that can stand up continuously under the high temperature of a boiler furnace.



SIMULTANEOUS RECORDS OF FURNACE TEMPERATURE AND CO_2 MADE BY COMBINED CO_2 METER AND PYROMETER

Dr. Kent has also frequently called attention to the fact, borne out by all efficiency tests, that the best results are obtained when the percentage of oxygen in the products of combustion ranges between 5 and 7 per cent, and he has strongly advocated the substitution of oxygen for CO_2 in the control of combustion efficiency.

I have shown also in my paper "Combustion and Boiler

[1] Trans. Am. Soc. M. E., vol. 32, p. 1215.

Efficiency" by coördinating the flue gas analyses of over 1100 boiler tests, that the percentage of oxygen increases as the percentage of CO_2 decreases, and vice versa. This relation necessarily follows from Alvogadro's law. When burning bituminous coal 7 to 5 per cent of O corresponds to about 11.5 to 14 per cent of CO_2, which is good practice. Theoretically, therefore, it would be quite immaterial which of these two constituents was adopted as the basis of control. Practically, however, CO_2 has everything in its favor; first, because it is very easily determined, whereas O is determined with greater difficulty, and second, because of this fact there is no oxygen recorder on the market, whereas there are several very good CO_2 recorders available.

There are two fundamental principles on which a bonus system can be established. It can be based (*A*) on the ratio of the heat output in the form of steam to the heat input in the form of fuel, or (*B*) on the ratio of the heat input to heat wasted up the chimney.

(*A*) If based on the boiler output we must know (*a*) the weight of coal fired under every individual boiler and (*b*) its average heat value for each shift and fireman. Second, we must know (*c*) the weight of water fed into every boiler, (*d*) its average temperature, (*e*) quantity wasted in blow offs, etc., for every boiler and shift, and also (*f*) the amount of superheat or priming. From these six factors the exact standing of every fireman in terms of efficiency can be calculated and the correct bonus determined.

To determine these data means must be provided (*a*) to weigh out the coal to every boiler for every shift, (*b*) to analyze every car of coal received, (*c*) to meter the water into every boiler, (*d*) to record its temperature, (*e*) to record the temperature and pressure of the steam, and last, the data must be promptly collected, correctly coördinated, and accurately calculated, for which important work a competent clerk must be available for every shift. To be an active stimulus for proficiency every fireman must be informed whether he earned a bonus, not later than the beginning of his next shift.

At the expense of accuracy this method may be materially simplified by assuming (*b*) that the coal is of uniform quality, (*d*) that the temperature of the feed water does not vary, (*e*) that the quantity of water blown off, etc., is the same for each boiler and shift, and (*f*) that the quality of steam is constant.

(*B*) If a bonus system is to be based on the heat wasted up the chimney, we must know (*a*) the average percentage of CO_2 in the products of combustion as they leave the boiler, (*b*) their average temperature, and (*c*) the rate of driving. These three factors give all the information necessary. (*a*) Determines the efficiency of combustion, (*b*) shows the efficiency of absorption, and (*c*) tells whether the fireman is doing his full share of the work. These three factors must be autographically and continuously recorded for the purpose of comparing and scrutinizing as well as for the purpose of estimating the bonus. Instruments are now available which will record these three factors on one chart. This reduces the number of charts from three to one, which reduces the time to scrutinize the records, and to average up and estimate their value to one-sixth or less of that required if the data must be taken from three separate charts.

To get the best results it is necessary that the fireman should know what he is accomplishing *all the time*. He must, therefore, have indicators at or near the boiler front which will continuously show the rate at which he is driving his boiler, the percentage of CO_2 he is producing and the stack temperature. With this information before him, he can see all the time whether he is operating on a bonus earning scale or not, and this knowledge will not only stimulate, but greatly aid him to get the best results. The pilot steam gauge used at the Delray Plant is an excellent idea, where the load varies greatly, as thus keeping the firemen continuously informed, obviates the necessity of making a written report to each fireman every day. Estimating the bonus once a week is quite sufficient. This reduces the clerical work required to a minimum.

Determining the bonus according to method (*A*) if fully carried out has in its favor great exactness, also that it shows the daily cost of steam production, and it also gives the necessary data, by which the coal can be purchased on the heat unit basis, the economic importance of which is not sufficiently realized by coal consumers.

On the other hand method (*B*) has in its favor greater simplicity, more general adaptability, and above all the immediate and continuous occular exposition of the complete process of heat production and absorption, and the continuous autographic record of the three controlling factors, in the best possible form.

The cost of the apparatus and appliances necessary will probably not differ greatly. The cost of up-keep and attendance, including the coal weighers and chemists, will no doubt be largely in favor of method (*B*). Either method if consistently carried out will give maximum efficiency.

The procedure necessary to establish the maximum normal efficiency obtainable in any given plant may vary greatly in detail, but the broad principle outlined by Mr. Polakov must be followed. Whether it is necessary to employ an expert depends on the availability of adequate home talent. Generally it pays to get expert advice. Unless the plant embodies fundamental defects, costly changes are generally not necessary to produce good results. In the majority of cases, it is only necessary to put the plant in proper working order, educate the firemen, or give them the means and the incentive to educate themselves, by inaugurating a bonus system.

Mr. Polakov raised the efficiency of the Warrior Ridge power plant from 54.2 per cent to 78.78 per cent by increasing the percentage of CO_2 in the flue gas from an average of 4.3 per cent to 12 per cent. The high efficiency established in this plant can be maintained only as the high percentage of CO_2 is maintained; there, as in every other case where high efficiency is attained, CO_2 is the most conspicuous single factor.

In conclusion a few words to those who claim that CO_2 recorders are unreliable, and they are continually getting out of order. They are neither infallible nor fool proof. In this they do not differ from any other apparatus or machine, a common pump for example. A steam pump is not a very complicated apparatus and is considered most reliable, but it will not draw water if the strainer is choked up, or a chip gets under the discharge valve. If such a pump be placed in some corner of a plant in charge of *nobody in particular*, it is a moral certainty that this pump would be inoperative the greater part of the time. Nine times out of ten that is the situation where CO_2 recorders of modern type (obsolete

apparatus are not considered here) fail to perform their legitimate function. In the majority of cases it is even worse because the pump would more than likely stand on neutral ground, whereas the CO_2 recorder is generally projected into a hostile camp. It is looked at askance from the beginning and considered a despicable telltale, at best as one of those new fangled ideas that won't work anyhow.

In not one case in ten where CO_2 recorders fail to perform their proper function does the cause lie in the instrument; nine times out of ten the fault lies with the man higher up, in that he does not hold some one person responsible for its proper and continuous operation. The failure to detail some one and hold him responsible is due either to lax management or to lack of confidence in his own judgment when he decided to install such an instrument.

If the troubles complained of were inherent in the apparatus, it would logically follow that the difficulties must multiply with the number of recorders installed, whereas practically all the failures rumored about, and nearly all the complaints received are from plants where only one recorder has been installed. It is apropos to say here that the benefit derived from the installation of CO_2 recorders is in inverse ratio of the completeness of the installation at best. A complete equipment always results in marked savings, whereas a single instrument rarely shows tangible results.

C. A. Austrom (written). In preparing his paper, Mr. Polakov has wisely emphasized the human element as an important factor in the economy of boiler operation. Previous speakers have all agreed with him on this point, but it occurs to me that most of these gentlemen had in mind mainly the larger steam installations, judging from several remarks, as for instance, Mr. Stott's regarding the fact that firing should be in the hands of educated and trained engineers, instead of as in the past by ordinary firemen. In large plants where the firing is done mechanically, this can be accomplished without much difficulty, but in the multitude of small steam plants I believe that we shall in the future, as well as in the past, see the shovels wielded by the old type firemen and not by college graduates.

Very little has been done to educate firemen in their line of work, considering the great importance of such an education from the viewpoint of both individual and national economy. The economical end of boiler operation is very little understood by the average fireman and some kind of treatise, dealing with the problems involved in the economical operation of boilers, written for the benefit of these men, has been a long felt need. Such a publication has recently been issued by the Travelers Indemnity Company of Hartford, and this, I believe, is the first attempt made along these lines. It deals with practically all the factors relating to boiler economy and should be of great help to firemen and owners of small steam plants.

Harrington Emerson (written). Efficiency in boiler plants is measured by the standards set. As elsewhere, everything depends on the value of the standards. The rational standard cannot be the ultimate attained in a test run where all conditions were momentarily perfect, as on a race course. Nevertheless the test run of today becomes the expected regular achievement of tomorrow if we are able to eliminate the unstandardized conditions and operations.

Mr. Polakov's paper is exceedingly valuable because it shows ways of standardizing conditions and operations in the boiler plant. The whole paper is so good that I feel less compunction in calling attention to an omission.

Most manufacturing operations consist of the wise combination of materials, work and equipment. In boiler plants manufacturing steam the materials are chiefly the fuel, the equipment is the whole boiler plant, and the attendants are the workers. The performance of the plant depends on the initial quality of the fuel as well as on the way it is used; it depends on the initial excellence of the equipment as well as on the way it is used; it depends on the *initial quality of the attendants* as well as on the way they are used. Before expecting continuous runs of high excellence we would provide for tests of the fuel so as always to have the standard amount of B. t. u. per lb. We would similarly continuously inspect and test furnace settings, boiler joints, clean off scale or deposit inside and out, etc., etc.

How can we expect best results unless the boiler room attendants have initial aptitude and are continuously maintained in effective condition? Mr. Polakov lays stress on fuel of the necessary condition, selection and use of fuel, selection and use of equipment, use of attendants, but omits reference to the selection of men. No one would think of raising a big crop, however excellent the climate, soil and tillage, from inferior seed. Mr. Polakov has emphasized the careful adjustment of work to men, but not the equally important adjustment of men to the work.

Frank B. Gilbreth (written). Four years ago I called the attention of this Society to the necessity of a government bureau for the collective cataloguing and disseminating of knowledge regarding management, that the best methods of each individual of each generation might be recorded for all. Mr. Polakov's paper not only shows a typical advance that is being made in management, but also in the conservation of our natural resources. It shows how workers can be taught to be more efficient, to waste less coal and at the same time how to earn higher wages, and how they can perform their duties without wasting their energy.

What Mr. Polakov says regarding chairs in the boiler room brings up the subject of chairs in general in the industries. Absence of chairs in the past in the workshops has been due to general ignorance on the part of managers, but there is now no longer any such excuse. Every act, every moment of unnecessary standing causes fatigue, and fatigue must be allowed for in the determination of a fair task for each worker.

In our work of installing management I have been greatly impressed with the evidenced unnecessary wasteful hardships due to the absence of recognized rest periods in all industries. Rest periods must be had, and therefore should be recognized, although the manager of one large machine shop said: "Sitting down even when there is nothing for the worker to do doesn't look well, and also makes him lazy."

Many occupations have periods of unavoidable delay, and thus require no specially assigned rest periods; while others have no such unavoidable rest periods, and therefore should have such properly timed and scheduled in order to get the best results, least fatigue, and greatest output.

With the idea of calling national attention to the need of devices for eliminating unnecessary fatigue, we have started at Providence a Museum of Devices for the Elimina-

tion of Unnecessary Fatigue in the Industries, and although we have caused to be sent out to date 55,000 notices, the only replies that we have received have been that they "were highly in sympathy with the idea," but as they "had never given the matter any thought before" they would "be unable to send any such devices for exhibition."

Mr. Polakov's paper is a distinct addition to the literature of the science of management. There is no end to the subject. There is still great work in this line to be done, too great to be done by any but a government bureau, and I again desire to call attention to the desirability of this Society using its influence to forward the movement for establishing a national bureau for the investigation, recording, cataloguing and dissemination of knowledge regarding the elimination of unnecessary waste in the industries, and thereby bettering the condition of the workmen.

ROGER DEWOLF[1] asked what the connection was, if any, between the blower supplying the air to the stoker and the drive for supplying the coal. He also wished to know if Mr. Parker would consider a semi-automatic control for the blower, at least as being a desirable proposition. A new equipment of 875-h.p. boilers was being installed in Rochester using a semi-automatic control on the blower and a motor-driven feed for the coal, which was entirely in the hands of the firemen for operating.

Mr. DeWolf agreed with Mr. Moultrop regarding the use of CO_2 recording meters, but would like to have further details. In this installation it was being arranged to measure the feedwater continuously in order to get continuous records of the feedwater and of the amount of coal burned, and it was expected to rely on these, together with steam flow meters on the boilers, rather than on any CO_2 determinations.

THE AUTHOR. In view of the fact that many of the points brought out in the discussion are general in character, I feel justified in emphasizing the main points.

First, the method of management as illustrated in our particular example is based on induction otherwise known as the method of scientific investigation. It is a basis of all modern positive science and is as old as Novum Organum of Francis Bacon. Applied to the art of management by Dr. Taylor it is known as "scientific management." The more exact is our knowledge of engineering sciences, psychology, physiology and political economy, the higher is our standard and the higher is the task. The accomplishment of the task is primarily based on the *system of education* of men engaged in the work. For this purpose *each particular case shall be studied individually* and all details—task, methods, implements, bonus, etc., must necessarily be concurrent with the existing conditions and circumstances.

Second, the task and bonus method is a most essential part of the power plant management, being an educational campaign with a reward to those who learn. This makes it unnecessary to hire a college graduate to shovel the coal in the furnace when he can train the others to do it well. Professor Jacobus is in sympathy with those "poor fellows who did not know the method employed by other men" and thereby missed their bonus; he sees the danger where actually lays the strong incentive for coöperation and improvements. This systematic education of the employees in order to improve their work and remuneration stands in the same relation to the selection of help as the method of using the equipment stands to its purchase.

Yet in the particular case related in my paper the question of selection is infinitely less pressing than that of supply. The location of the plant I have reference to is such that to secure any employee or summon a man to help in case of emergency often amounts to an impossibility, and the problem is not whom to hire but where to find anyone. Under such conditions we must say with all due credit to the importance and desirability of proper selection of employees, that the method of training green, and sometimes unfit, men and turning them rapidly into valuable producers is far more important. The race track is the testing department; no one would think of running a race with a dray horse, but the profit of a trucking business depends upon the skill of the drivers and planning of deliveries, and not on pedigree alone.

Third, in the past too much stress was laid on the physical perfection of equipment and this one-sided engineering is so well rooted in the minds of average managers that nearly all industrial ills and losses were believed curable by "patent" devices. Used by untrained and often underpaid and indifferent "hands," they fail to pay for their first cost. It matters not whether after rebuilding the furnaces, baffles, etc., and changing fuel the various boilers will give the characteristic curves of the same value. The most suitable coal might not be obtainable at the desired cost and the reconstruction might be impracticable under the conditions of service. The question is whether with obtainable fuel and existing equipment we know how to get all we can for the dollar's worth; and if not, to learn how the desired result could be obtained. Unless we teach and stimulate the employee to strive at the high task, the best equipment, if purchased, will again run in a haphazard manner.

And lastly, to utilize the knowledge to the fullest advantage and to control the process at will, the conditions, not results, must be watched and regulated. The instruments will show the changes of conditions, and instruction cards must tell what to do; then if the cause is properly treated, the result is gratifying whether it appears on the CO_2 chart, on auditor's balance sheet, or is reckoned in thermodynamic terms.

[1] Mechanical Engineer, Rochester Railway & Light Company, Rochester, N. Y.

RAILROAD SESSION

PAPERS CONTRIBUTED AT THE ANNUAL MEETING BY THE SUB-COMMITTEE ON RAILROADS

STEEL UNDERFRAME BOX CARS

By George W. Rink, Jersey City, N. J.
Member of the Society

In approaching a subject of such importance to railroads as steel underframe box cars, it is surprising, in view of the interchange of such cars among the railroads, that more has not been accomplished during the past five years toward standardization in design of the various component parts, particularly those which affect the cost of maintenance and require constant repairs due to wear and unavoidable accidents.

During the year 1912, there were built 107,887 box cars of various capacities and dimensions, all varying vastly in detail design of important parts which require frequent renewal, thus making it necessary for all railway storehouses to carry an unnecessarily large stock of repair parts running into very large sums of money. Standards have been adopted by the Master Car Builders' Association which have in a large measure reduced the amount of stock necessary to be carried. I believe the time has arrived to introduce additional standards affecting the maintenance of box cars which can also be applied to all types of freight cars used in interstate business.

It is reasonable to assume that every railroad manager desires to purchase cars built in a substantial manner. In the absence of standard construction and because of competition, the car builders, when asked to furnish estimates and designs, will sometimes figure on material too light for the service. This, however, is not the fault of the car builder, since, from my own experience, I know that they will gladly add the material where needed, provided they are paid a fair price for the car.

From my observation of steel underframe box cars, I must conclude that engineers did not understand the importance of low fiber stresses in the early designs of steel underframes; sufficient attention was not given to the tremendous impact blow which the center sills and car framing found it necessary to resist, with the result that large sums of money are now being spent by railroads in making repairs to these cars by reinforcing broken center and draft sills, applying larger capacity draw gears and attachments, and heavier sills. It is not alone the larger locomotives we are using today which has called for a more thorough investigation of the subject of car design and construction, but also the severe shocks which cars are receiving in classification yards. Also the superstructure of box cars should receive just as much attention as the underframe, for how can the roofs be kept in alignment on cars having wood side posts and braces and loose tie rods. The roof is bound to work loose, resulting in leaks which prevent the use of the car for certain commodities.

The application of steel underframes to old cars will no doubt prolong their lives. This is now being done by almost every railroad on cars built just prior to the advent of all-steel underframe box cars, but care should be taken, to see that sufficient metal is provided to withstand the present service requirements, keeping in view a margin of safety for the future, as no doubt it would be desirable to maintain in service for at least ten years cars to which these steel center sills were applied. The reinforcement of the ends of box cars has received attention by the Car Construction Committee of the Master Car Builders' Association, and they have presented recommendations in the way of designs for old and new box cars. This committee likewise made recommendations with a view to establishing minimum area of center sills to resist end strain.

Railway officials in charge of car repairs have seen the results of poor designing and light construction of the earlier steel underframe cars, and during the past three years have materially assisted in the development of the art by insisting upon the production of a stronger car, one that will hold together in all kinds of service with the minimum cost of repairs.

I have compiled certain relative data from designs of eight wooden upperframe cars and one steel frame car, all of which have inside lining and outside sheathing, also six steel upperframe cars with only inside lining. All of these cars represent the latest designs of box cars now being built or recently placed in service by various railroads. The data obtained have been divided into the following groups, special cars for automobiles and furniture having been disregarded:

Table 1 General dimensions of box cars with outside sheathing

Table 2 General dimensions of box cars with inside sheathing

Table 3 Dimensions of wood side framing

Table 4 Dimensions of steel side framing

Table 5 Dimensions of end framing for cars with wood side frames

Table 6 Dimensions of end framing for cars with steel side frames

Table 7 Dimensions of side door openings, size of door and distance from rail to top of floor

Presented at the Annual Meeting, December 1913, of The American Society of Mechanical Engineers.

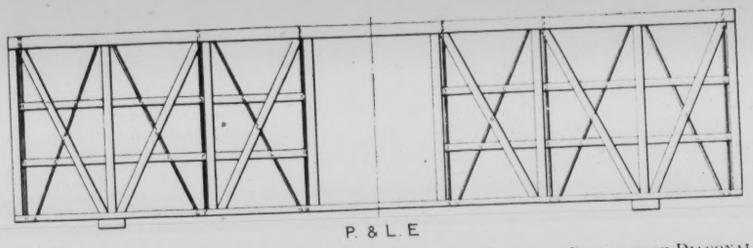


Fig. 1 Side Frame used on P. & L. E. Car Showing Wood Posts and Braces with Diagonal Rod Bracing

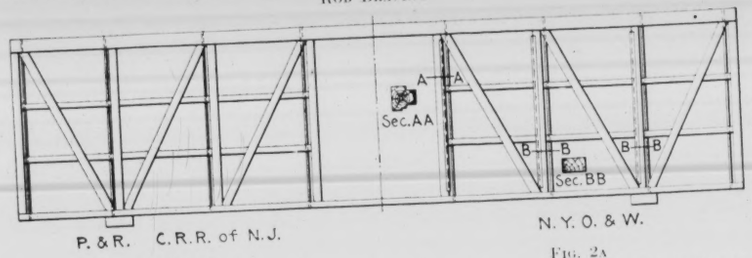


Fig. 2 Fig. 2a

Fig. 2 Side Frame used on P. & R. and C. R. R. of N. J. Cars with Wood Posts and Braces

Fig. 2a Side Frame used on N. Y. O. & W. Cars with Wood Posts and Braces; Posts Reinforced by Channels

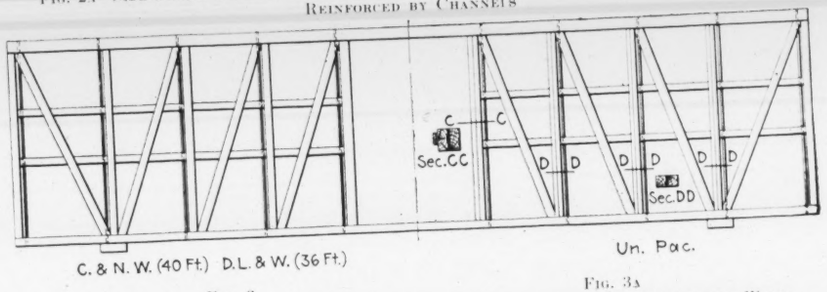


Fig. 3 Fig. 3a

Fig. 3 Side Frame used on C. & N. W. and D. L. & W. Cars having Nine Panels with Wood Posts and Braces. Type of Frame Adopted by the M. C. B. Association for Cars of 80,000 and 100,000 lb. Capacity

Fig. 3a Side Frame used on Un. Pac. Car having Nine Panels with Wood Posts and Braces; Posts Reinforced by Plate

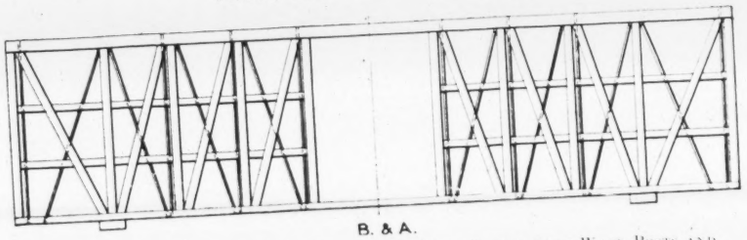


Fig. 4 Side Frame used on B. & A. Car having Nine Panels with Wood Posts and Diagonal Rod Bracing

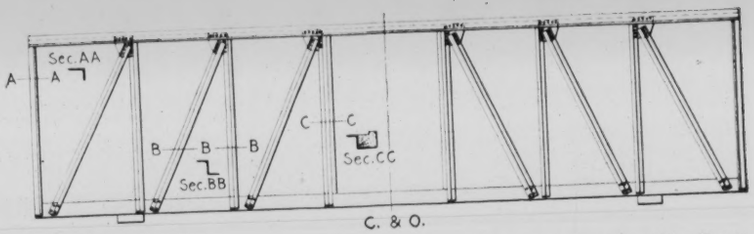


Fig. 5 Steel Side Framing used on C. & O. Car having Seven Panels with End Panel Braced Diagonally; Structural Material used

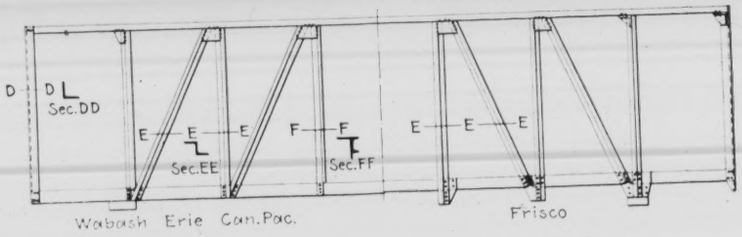


Fig. 6 Fig. 6a

Fig. 6 Steel Side Framing used on the Wabash, Erie and Can. Pac. Cars having Seven Panels and no End Panel Bracing; Structural Material used

Fig. 6a Steel Side Framing used on Frisco Car with Seven Panels and no End Panel Bracing; Structural Material used

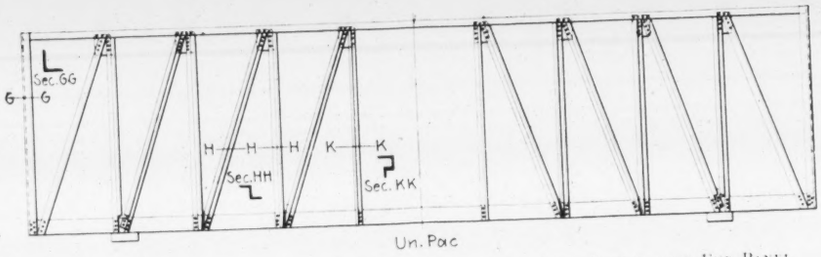


Fig. 7 Steel Framing used on the Un. Pac. Car having Nine Panels with End Panel Braced Diagonally; Side Door Posts Pressed Steel Section and Angle Iron

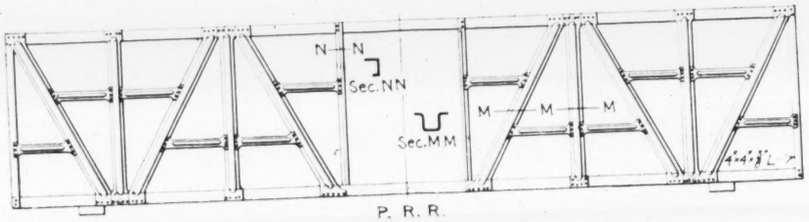


Fig. 8 Steel Side Framing used on P. R. R. Car with Seven Panels with End Panel Bracing from Bolster to Side Plate at End; Pressed Steel U-Sections with Flattened Ends for Securing to Side Plate and Side Sill

Table 8 Dimensions of running boards, type of roof and carline, width and height at eaves, etc.

Table 9 Distance between body bolsters, spread of truck wheels, etc.

Table 10 Dimensions of draft sills, side sills, floor supports, etc.

Table 11 Area, section moduli, etc., of steel underframes at center for cars with wood side frames

Table 12 Area, section moduli, etc., of steel underframes near bolster for cars with wood side frames

Table 13 Area, section moduli, etc., of steel underframes at center for cars with steel side frames

Table 14 Area, section moduli, etc., of steel underframes near bolster for cars with steel side frames

Table 1. By referring to this table, it will be noted that the inside dimensions, such as length and width for 36-ft. box cars are the same with but one exception—the inside height varies considerably, due to the type of the carline used. The American Railway Association adopted on October 23, 1901, standard inside dimensions for box cars as follows: length, 36 ft.; width, 8 ft. 6 in.; height, 8 ft. No recommendations were made by the Master Car Builders' Association, as requested by the American Railway Association, to establish external dimensions for the 36-ft. box car. By referring to the table it will be noted that the length over sheathing varies from 36 ft. 10¼ in. to 37 ft. 1⅛ in., with length over striking plates varying from 37 ft. 7⅝ in. to 38 ft. 8⅞ in., the variation being accounted for by the use of different types of end construction. No doubt these differences will continue on future designs of cars until a standard end frame and end sill construction is made compulsory.

Table 2. This shows similar dimensions for types of steel side frame cars, and it would appear that the inside dimensions, especially of the long cars, are made to suit the whims of various designers. There is really no excuse for such a condition, as it means a further drifting away from the car of standard dimensions which should by reason of duplication in all its parts, facilitate repairs, bearing in mind that it is going to be a more costly proposition for railroads to repair, and at times replace, parts of damaged superstructures of steel frame cars than when made of wood. It appears that there was a demand for larger cars than those adopted by the American Railway Association. At a meeting of this body held November 20, 1912, the Committee on Standard Dimensions for Box Cars, after ascertaining the clearances of various railroads, decided that a box car 40 ft. 6 in. long, 8 ft. 6 in. wide and 9 ft. high was the largest car which could be constructed with due regard for clearances. I believe it undesirable to increase the inside height of the car to 9 ft. on account of increasing the height of the center of gravity of the car from the top of the rail. The present inside cross dimensions should be maintained, and the car should simply be lengthened to 40 ft. in order to obtain increased cubic capacity. Attention is also called to the great variations in weight of cars shown in Tables 1 and 2, which leads me to believe that either some of the cars are built too light or others are carrying excess weight in the way of material not properly distributed.

TABLE 1 GENERAL DIMENSIONS OF BOX CARS WITH OUTSIDE SHEATHING

Road	Capacity	Light Weight of Car	Inside Dimensions			Length Over			Width Over Side Sills
			Length	Width	Height	Striking Plate	End Sill	Sheathing	
D. L. & W.	60,000	37,300	36′ 0″	8′ 6″	8′ 0″	37′ 7⅝″	*36′ 8⅝″	36′ 10¼″	9′ 0½″
C. R. R. of N. J.	60,000	39,000	36′ 0″	8′ 6″	8′ 0″	38′ 3½″	37′ 6½″	37′ 1⅛″	9′ 1″
P. & L. E.	80,000	39,600	36′ 0″	8′ 6″	8′ 4″	38′ 0½″	36′ 10¾″	37′ 0⅜″	9′ 2″
N. Y. O. & W.	80,000	40,000	36′ 0″	8′ 6″	8′ 2½″	38′ 8⅞″	37′ 10⅞″	36′ 11¾″	9′ 1⅜″
P. & R.	80,000	48,100	36′ 2″	8′ 7″	8′ 2⅛″	38′ 2½″	*37′ 0″	37′ 1¼″	9′ 2″
B. & Albany	80,000	39,800	36′ 0″	8′ 6″	8′ 4″	38′ 1″	36′ 10¾″	37′ 0⅜″	9′ 2″
C. & N. W.	80,000	41,200	40′ 0″	8′ 5¼″	7′ 11½″	41′ 10⅞″	40′ 9½″	40′ 11⅜″	9′ 1¾″
Un. Pac.	100,000	42,700	40′ 0″	9′ 1¾″	9′ 2¼″	42′ 1¼″	*40′ 8⅜″	40′ 9⅞″	9′ 8½″
C. & O.	80,000	39,700	36′ 0″	8′ 6″	8′ 0″	38′ 6½″	*37′ 10½″	36′ 11¼″	9′ 1⅞″

* Between end sills.

Table 3. This table is very interesting in pointing out what various designers consider necessary in the way of sizes of material for posts and braces which make up the wooden body frame, the general arrangement of which is shown in Figs. 1 to 4. In 1904, the style of framing recommended by the Master Car Builders' Association, and shown in Fig. 2, was adopted for cars of 60,000 lb. capacity, and that shown in Fig. 3, for cars of 80,000 to 100,000 lb. capacity. There is this one exception, however, that the Master Car Builders' design indicates the use of one belt rail, whereas, it is now necessary to provide two belt rails in order properly to secure the outside sheathing. This extra rail also adds materially to the rigidity of the side frame, assisting it against end strains.

Table 4. In this table is shown a comparison on sizes of material used in different members of the steel frame box car. This type of framing, as applied to a large number of box cars recently constructed, lends itself very readily to standard construction; and it is well to note that, with the exception of intermediate posts and braces, we are again confronted with a va-

TABLE 2 GENERAL DIMENSIONS OF BOX CARS WITH INSIDE SHEATHING

Road	Capacity	Light Weight of Car	Inside Dimensions			Length Over			Width over Side Sills
			Length	Width	Height	Striking Plate	End Sill	End Posts	
Erie	80,000	38,800	36′ 0″	8′ 6½″	8′ 0½″	38′ 1¼″	*36′ 11½″	36′ 11½″	8′ 9½″
Can. Pac.	80,000	38,300	36′ 0″	8′ 6½″	8′ 0½″	38′ 1¼″	*36′ 11½″	36′ 11½″	8′ 9½″
Wabash	80,000	36,200	36′ 5⅝″	8′ 6″	8′ 0″	38′ 5⅝″	*37′ 4⅞″	37′ 4⅞″	8′ 9¼″
Frisco	80,000	40,700	40′ 0″	8′ 6″	8′ 0″	42′ 0¾″	*40′ 11″	40′ 11″	8′ 8¼″
Un. Pac.	100,000	41,800	40′ 5⅜″	9′ 2″	9′ 0″	42′ 1¼″	40′ 8⅜″	41′ 4⅜″	9′ 5″
P. R. R.	100,000	47,900	40′ 6″	8′ 10″	8′ 0″	42′ 6″	42′ 6″	41′ 8½″	9′ 0½″

* Between End Sills.

riety of sections and weights of materials comprising the side plate, side sill, corner and door posts. There is no good reason why this condition should continue; these cars will be in service practically all over the country, and barring wrecks, the frames will be subject to the same stress due to impact blows, car lading and weight of superstructure.

The general designs of steel side frames are shown in Figs. 5 to 12. It will be noted that standard structural material has been used throughout, with the exception of the Pennsylvania Railroad box cars. The design of frame of this railroad, shown in Fig. 8, makes a splendid appearance, is well arranged and provides for vertical inside sheathing. Due to the construction of the posts and braces, slight contact blows from obstructions on neighboring tracks will not affect the appearance of the brace as they will if structural steel is used, which is more liable to distort. However, I am not in favor of pressed steel, on account of its higher first cost as compared with stock rolled steel and also of the fact that the ends of the posts and braces are flattened out where they connect to the side sill and plate, thus weakening them, especially at the bottom, where depth of the member is desirable to resist bending due to shifting of load or side impact blow.

I prefer the frame construction shown in Fig. 7, for cars having an inside length of 40 ft. or over and the same construction for cars 36 ft. inside length, omitting one panel from each side. A diagonal brace has been introduced in the end panel and is in tension due to lading, thus relieving the stress on the side sill near the bolster. It also ties the lower corner of the side frame. If the corner post were to receive an end blow directly over the push pole pocket, with the assistance of an end diagonal it would keep the panel square. Several designs (Figs. 6 and 6a) show omission of this brace, but for what reason I do not know, as it could be used to advantage also to secure the inside lining in this panel of wide span.

The question of frame design will depend largely on how the sheathing is to be extended, i. e., vertically or horizontally. The sheathing extends horizontally for all designs of steel frames shown, except for the pressed steel frame. I believe vertical sheathing is preferable as it protects the lading against water. In the case of horizontal sheathing, rain can beat in at the joints and the grooves or beading form gutters that have a tendency to deposit the water into the car, both at the door and end posts. This is an important question in the case of cars used for transporting grain. Standard size sheathing should also be adopted. Referring to the last column in Table 4, the thickness varies from 1¼ in. to 1⅝ in. and the width from 3¼ in. to 5¼ in. It is reasonable to assume that if all roads having cars built of this type were to use a uni-

TABLE 3 DIMENSIONS OF BODY SIDE FRAMING—WOOD CONSTRUCTION

Road	Capacity	Length over Sheathing	Side Posts	Side Braces	Side Plates	Corner Posts	Side Door Posts	Belt Rail		Style of Frame
								Size	No.	
D. L. & W.	60,000	36′ 10¼″	5″x2⅜″ with ⅜″x2¼″ Pl.	5″x2⅜″	6¼″x3¼″	5″x5″ with 3″x3″x 5/16″ L.	5″x4¾″	4½″x2⅜″	2	Fig. 3
C. R. R. of N. J.	60,000	37′ 1⅛″	5″x2½″	5″x2½″	7½″x3″	4″—7½ lb. I 4″x5½″wood 2⅜″x4″filler	4½″x4⅜″	4″x3½″	2	Fig. 2
P. & L. E.	80,000	37′ 0⅜″	5″x3″	5″x3″	6″x4″	5½″x5½″	5½″x5 1/16″	4½″x3″	2	Fig. 1
N. Y. O. & W.	80,000	36′ 11¾″	5″x3″ and 3″—4 lb. [	5″x3″	7½″x4″	5″x5″	5½″x5″ and 3″—4 lb. [	3½″x3″	2	Fig. 2a
P. & R.	80,000	37′ 1¼″	6″x3⅜″	6″x2 9/16″	8″x3″	7¼″x7″	6″x4⅞″	6″x3⅜″	2	Fig. 2
B. & Albany	80,000	37′ 0⅜″	5″x3″	5″x3″	6¾″x4″	5½″x5½″	5½″x5½″	4½″x3″	2	Fig. 4
C. & N. W.	80,000	40′ 11⅛″	5″x3¾″	5″x2¾″	6″x3″	6″x5½″	5″x4 11/16″	4″x2¾″	1	Fig. 3
Un. Pac.	100,000	40′ 9⅞″	5″x2½″ and ½″x2¼″ Pl.	5″x2½″	7″x3½″	5″x5″	6″x4¾″ and ½″x4½″ Pl.	4″x2½″	2	Fig. 3a

TABLE 4 DIMENSIONS OF BODY SIDE FRAMING—STEEL CONSTRUCTION

Road	Capacity	Side Sills	Length over End Posts	Side Posts	Side Braces	Side Plates	Corner Posts	Side Door Posts	Inside Sheathing	Size of Sheathing	Style of Frame
C. & O.	80,000	8"—11¼ lb. [5½"x3" wood	36' 9⅝"	3"—6.7 lb. Z	3"—6.7 lb. Z	3½"x3"x 5/16"∠ 2½"x5" wood	4"x3"x 5/16"∠ 5"x4" wood	3"—6.7 lb. Z 4¾"x3¾" wood	Horizontal	13/16"x5¼"	Fig. 5
Erie	80,000	8"—11¼ lb. [flanges in	36' 11½"	3"—6.7 lb. Z	3"—6.7 lb. Z 3 1/16"—8.4 lb. Z	4"—8.2 lb. Z	5"x5"x⅜"∠	5"x3½"x 5/16"∠ with 3"—4 lb. [	Horizontal	1½"x5¼"	Fig. 6
Can. Pac.	80,000	8"—11¼ lb. [flanges in	36' 11½"	3"—6.7 lb. Z	3"—6.7 lb. Z 3 1/16"—8.4 lb. Z	4 1/16"—10.3 lb. Z	5"x5"x⅜"∠	5"x3½"x 5/16"∠ 3"—4 lb. [	Horizontal	1½"x5"	Fig. 6
Wabash	80,000	8"—11¼ lb. [flanges in	37' 4⅞"	3"—6.7 lb. Z	3"—6.7 lb. Z	3"—6.7 lb. Z	4"x4"x¼"∠	3"—6.7 Z	Horizontal	1⅝"x5¼"	Fig. 6
Frisco	80,000	5"x3"x⅜"∠ 3"x4⅝" wood	40' 11"	3"—6.7 lb. Z	3"—6.7 lb. Z 3 1/16"—8.4 lb. Z	4"x3"x 5/16"∠	5"x4"x⅜"∠	4"—8.2 lb. Z	Horizontal	1½"x3¼"	Fig. 6a
Un. Pac.	100,000	9"—13¼ lb. [flanges in	41' 4⅜"	3"—6.7 lb. Z	3"—6.7 lb. Z	4"—8.2 lb. Z	5"x5"x⅜"∠	5"x3½"x 5/16"∠ Pressed U shape	Horizontal	1½"x5¼"	Fig. 7
P. R. R.	100,000	6"x4"x⅜"∠	41' 8½"	¼" Pl. Pressed U shape	¼" Pl. Pressed U shape	4"x6"x⅜"∠	4"x4"x⅜"∠	Bulb Angle	Vertical	1¼"x5¼"	Fig. 8

form size of material, it would be far easier and cheaper to make repairs.

Table 5. This shows the various sizes of material used in end frame construction for cars with wood side frames. Various designs have been introduced, which are shown in Figs. 13 to 19. The use of I-beam posts seems to predominate, using wood fillers on each side for securing the belt rails; this forms an ideal construction when the posts are well secured to malleable iron pockets at top and bottom, in connection with a heavy end plate and with bottom pockets riveted to the end sill cover plate. Braces have also been introduced extending, as a rule, from the end sill corner to the end plate adjacent to the posts. No doubt this location is preferable on cars with wood framing on account of the practice of extending the side brace in end panel from the bolster to the top of the corner post.

For securing the end frame against movement at the bottom, due to shocks occasioned by the shifting of loads, an arrangement of angle irons, located on and extending across the top of the end sill and secured by rivets to the top plate, appears to be excellent. This angle iron is placed directly against the posts or sheathing. The former practice is preferable but it is necessary to cut out the sheathing at the bottom where it laps over the angle iron. Steel plates are also being introduced on the inside of box cars as shown in Fig. 17, this plate extending from the floor line to the top of the upper belt rail and well secured to the corner posts by metal bands, which extend back to the door posts. It will be noted that in this construction the end posts are of wood and braced on the outside of sheathing by two pressed steel braces extending across the car, secured to the corner posts. This arrangement was recommended by the Master Car Builders' Committee on Car Construction as a desirable method for rebuilding the ends of wooden cars with Master Car Builders' lining.

It is a known fact that cars built some ten or fifteen years ago were fitted up with a type of end framing which was very light in construction. No post or brace pockets were used in some cases, and in other cases where pockets were used, the metal re-inforcement of the wood posts, such as channels, etc., did not extend into the pocket. When these ends were changed over to that shown in Figs. 14 and 16, with 1¾ in. end lining, no further trouble was experienced. From my

TABLE 5 DIMENSIONS OF END FRAMING FOR CARS WITH WOOD SIDE FRAMING

Road	End Sills	End Plates	End Posts	End Braces	Corner Posts	Type of Frame
D. L. & W.	9"—15 lb. [, flanges out; also 3"x3"x 5/16"∠ inside	3½"x11¾"	2—5"x3⅜" reënforced with 3"x3"x 5/16" ∠	5"x3⅜"	5"x5" with 3"x3"x 5/16"∠	Fig. 19
C. R. R. of N. J.	12"—40 lb. [, flanges in ¼"x10" Pl. & 3"x2½"x 5/16"∠ top	4"x13½"	4"—7½ lb. I with 2—2⅜"x4" fillers	4"x4"	4"—7½ lb. I 4"x5½" wood 2⅜"x4" filler	Fig. 16
P. & L. E.	⅜"x10¾" Pl. 4"x4½"x⅜" ∠ top 3"x3"x⅜"∠s top and bott. inside	4"x12"	4"—7½ lb. I with 2—2"x4" fillers	5"x4"	5½"x5½"	Fig. 13
N. Y. O. & W.	12"—20.5 lb. [flange in ¼"x12" top Pl. 3"x2½"x¼"∠ top	4"x13"	4"—7½ lb. I with 1—4"x2½" wood filler	4"x4"	5"x5"	Fig. 14
P. & R.	13"—32 lb. [flanges out & cast iron filler 3"x2"x 5/16"∠ top	4"x15¼"	6"x4" with 3/16"x6'—1¾" Plate	None	7¼"x7"	Fig. 17
B. & Albany	½"x10" Pl. 5"x3½"x⅜"∠ top 3"x3"x⅜"∠s top and bott. inside	4"x12"	4"—7½ lb. I with 2—2 7/16"x4" fillers	5"x4"	5½"x5½"	Fig. 13
C. & N. W.	6"x9¼" wood with ½"x9" Plate in rear	3"x14⅛"	5"—9¾ lb. I with 2—3⅛"x5" fillers	5"x3"	6"x5½"	Fig. 15
Un. Pac.	8"—13¾ lb. [flanges out 3½"x3"x 5/16"∠ top inside and 5"x5 1/16" wood	3⅜"x13"	5"x4⅜" with ½"x3½" flitch plate	5"x3⅜"	5"x5"	Fig. 18

FIG. 9 40-TON OUTSIDE STEEL FRAME BOX CAR USED ON FRISCO SYSTEM

personal experience, therefore, I do not believe an all-steel end is necessary to apply to wood side frame box cars.

Table 6. This shows various sizes of material used in end frame construction for cars with steel side frames, and the arrangements of posts and braces are shown in Figs. 20 to 25. Referring to Fig. 23, it will be noted that the diagonal brace has been omitted from the side panels; the brace has also been omitted from the end panel on the side frame and due to absence of both braces, especially the latter, I am of the opinion that the corners of the car are not sufficiently supported, and a side blow on the corner post near the eaves will result in distortion of the entire end of car. My attention was recently called to a car with end posts arranged as shown in Fig. 22; this car had received a side blow at the point in question and the entire end frame at the top took a permanent set of 4 in. from the vertical. For this reason, I believe diagonal braces extending from the side plate to the end sill near the center of car is a very desirable feature.

Z-bars appear to be well adapted for end posts and braces, and where set behind the end sill the best results will be obtained against strains due to end load shifting, as the entire section of metal in the Z-bar is subjected to shear. In this case it would appear desirable to use channel end sills with steel cover plate. By referring to Table 6, the variety of material used in the making of end sills may be noted. Here is where a standard construction could be made up along with striking plate, push pole pockets, corner post angles, etc., to advantage. Cars with inside sheathing should have end sills designed on standard lines, as it is a part of the car constantly requiring attention, especially in the vicinity of the end sill striking plate.

Referring to Fig. 25, the end construction for new cars as recommended by the Master Car Builders' Car Construction Committee may be noted. This design is evidently worked up on lines similar to those applied to the recent design of Pennsylvania box cars as shown in Fig. 24, the difference being in the use of rolled steel instead of pressed steel. I would hesitate to apply this construction to a new car, as I believe a good connection can not be made to the top of the end sill of the

TABLE 6 DIMENSIONS OF END FRAMING FOR CARS WITH STEEL SIDE FRAMING

Road	End Sills	End Plates	End Posts	End Braces	Corner Posts	Section Moduli of Posts and Braces	Type of Frame
C. & O.	8"—11¼ lb. [flanges out ¼"x14" top plate	4"x12" wood 4"—5¼ lb. [at bottom	2—4"—7½ lb. I with 1—3¾"x 13/16" and 1—2½"x4" fillers	2—4"—8.2 lb. Z	4"x3"x 1/16"∠ 5"x4" wood	12.28	Fig. 20
Erie	10"—15 lb. [flanges out ¼"x12" top cover Plate	Pressed steel Z shape	2—4"—8.2 lb. Z	None	5"x5"x⅜"∠	6.28	Fig. 23
Can. Pac.	10"—15 lb. [flanges out ¼"x12" top cover Pl.	Pressed steel Z shape	2—4"—8.2 lb. Z	None	5"x5"x⅜"∠	6.28	Fig. 23
Wabash	8"—13¾ lb. [flanges out ¼"x12" top cover Pl.	Pressed steel Z shape 3/16"	2—4"—8.2 lb. Z 2—3"—6.7 lb. Z	None	4"x4"x¼"∠	10.12	Fig. 22
Frisco	8"—11¼ lb. [flanges out ¼"x12" top cover Pl.	Pressed steel Z shape	2—4"—8.2 lb. Z 2—3"—6.7 lb. Z	None	5"x4"x⅜"∠	10.12	Fig. 22a
Un. Pac.	9"—13¼ lb. [flanges in ¼"x8" top cover Pl.	5"x3"x 5/16" ∠	2—4"—8.2 lb. Z	2—4"—7¼ lb. [	5"x5"x⅜"∠	6.98	Fig. 21
P. R. R.	Pressed steel Z shape upper leg 23⅝", lower leg 5⅛"	Pressed steel	1 Pressed steel U shape	2 Pressed steel U shape	4"x4"x⅜"∠	14.94	Fig. 24

Fig. 10. 40-Ton Outside Steel Frame Box Car used on Wabash R. R.

single post and two braces as shown. Again, this framing is not adapted to the application of end doors, which a good many roads find it desirable to apply on account of the loading of lumber, rails, etc. My preference is for a similar structure, using two posts, instead of one, with a diagonal brace each side similar to Fig. 20, having all posts and braces pass below the top of the end sill, for the reasons already mentioned. The short vertical plate behind the posts is desirable, and along with the wood lining, should make a practical arrangement.

Table 7. This table gives the sizes of door openings and sizes of doors used on recently constructed box cars. Of all the things which should be made standard, a box car side door is one of the most important. The Master Car Builders' Association now has a door standard, 6 ft. 5 in. wide and 8 ft. high, and it is endeavoring to make this standard for new as well as old equipment. How many railroads are following this practice, which was recommended by their committee in 1910 and adopted as standard in 1912? By consulting this table, it will be noted that but one railroad, the New York, Ontario & Western, has applied doors of this size.

It has been the practice to use door hangers with rollers, in order to permit the door to slide easily. Some cars were recently constructed with heavy doors, but rollers were omitted from the hangers, and I have learned from good authority that they are not satisfactory, as a great deal of exertion is required to operate them. My recommendation is to continue the use of hangers with rollers. Also sufficient number of door guides, as recommended by the Master Car Builders' Association, is not being applied; they are safeguards

TABLE 7 DIMENSIONS OF SIDE DOOR OPENINGS, SIZE OF DOOR AND DISTANCE FROM RAIL TO TOP OF FLOOR

Road	Distance from Rail to Top of Floor	Side Door			No. of Door Guide Brackets
		Opening	Size	Type	
D. L. & W.	4′ 0½″	6′ 0″x7′ 6½″	6′ 6″x7′ 11½″	M. C. B.	2
C. R. R. of N. J.	3′ 8″	6′ 0″x7′ 6½″	6′ 5½″x7′ 10⅝″	M. C. B.	4
P. & L. E.	4′ 0″	6′ 0″x8′ 0 9/16″	6′ 6¾″x8′ 2½″	M. C. B.	4
N. Y. O. & W.	4′ 1⅛″	6′ 0″x7′ 8″	6′ 5″x8′ 0″	M. C. B.	3
P. & R.	3′ 7⅞″	6′ 0″x7′ 6¾″	6′ 6½″x8′ 2½″	Square Frame	5
B. & Albany	4′ 0″	6′ 0″x8′ 0″	6′ 6¾″x8′ 2½″	M. C. B.	4
C. & N. W.	4′ 1⅛″	5′ 0″x7′ 5½″	5′ 2⅝″x7′ 8″	Not M. C. B.	4
Un. Pac.	3′ 9 11/16″	6′ 0″x8′ 8⅞″	6′ 6¾″x9′ 1″	M. C. B.	2
C. & O.	3′ 11 11/16″	5′ 6″x7′ 6¼″	5′ 9″x7′ 9½″	Square Frame	2
Erie	4′ 1″	6′ 0 1/16″x7′ 7 1/16″	6′ 3¼″x7′ 8 11/16″	M. C. B.	4
Can. Pac.	4′ 2¼″	5′ 0″x7′ 8″	5′ 4¾″x7′ 10⅛″	M. C. B.	2
Wabash	4′ 0¼″	6′ 0″x7′ 7¾″	6′ 5″x7′ 10¾″	M. C. B.	2
Frisco	4′ 1″	6′ 0″x7′ 7⅜″	6′ 7 1/16″x7′ 9 11/16″	Not M. C. B.	4
Un. Pac.	3′ 9 11/16″	6′ 2″x8′ 7″	6′ 6⅝″x8′ 9 3/16″	M. C. B.	4
P. R. R.	3′ 7½″	6′ 0″x7′ 3⅝″	6′ 3⅞″x7′ 9¾″	⅛″ Steel	2

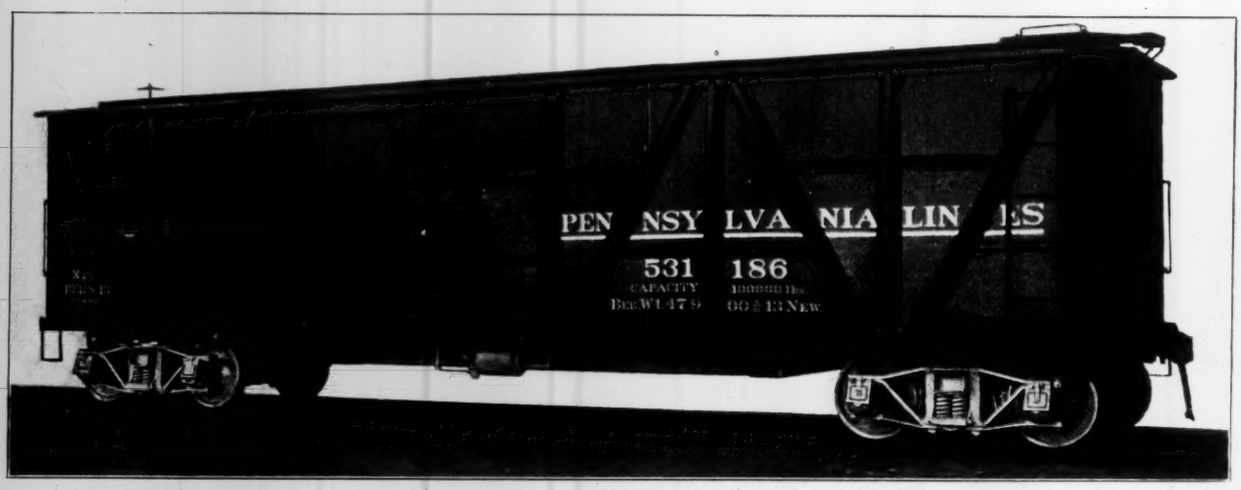


FIG. 11. 50-TON OUTSIDE STEEL FRAME BOX CAR USED ON P. R. R.

against accident if a door hanger should fail, and four guides should be applied as required.

The height from rail to top of floor shown in Table 7 varies somewhat from the Master Car Builders' standard of 4 ft. There is no reason for this oversight on the part of motive power officials, and it is of considerable importance as it permits of standard unloading platform heights all over the country, making it easier for electric freight handling trucks to enter the cars on the same level.

Table 8. This table gives some idea of the variety of roofs and roof carlines applied to recent box cars. The number of carlines required seems to be a disputed matter and evidently has been left to the manufacturer who supplies the roof. The essential requirements for a carline are to support the weight of the roof, with a suitable allowance for additional loading due to accumulation of snow and ice, and which is of equal importance, to prevent the sides of the car near the eaves from spreading due to lading.

As car roofs are now receiving considerable attention by motive power officials, I will describe the various types in use. They are usually divided into three classes, known as inside roofs, outside roofs, and all-steel roofs. The classification, inside roof, covers all types of car roofs where the metal is inside of the car, and the roof boards over this metal are on the outside of the car. The classification, outside metal roof, covers car roofs where the steel is on the outside of the car, and the roofing boards are underneath. The classification, all-steel roof, covers a car roof in which a heavy sheet is used, usually about 16 U. S. gage material. In this case, no roof boards are used, either above or under the roofing sheets.

The inside metal roof is the oldest type of roof in service. The original freight car roof consisted of either single or double sheathing of boards on top of the car, but the strain on these roofs was such that they could not be kept without continual repairs. The inside metal roof was then developed and being made of separate flexible units, permitted weaving of the car to take place and still have a waterproof roof be-

TABLE 8 DIMENSIONS OF RUNNING BOARDS, TYPE OF ROOF AND CARLINES, WIDTH AND HEIGHT AT EAVES, ETC.

Road	Type of Carline	No. of Carlines	Type of Roof	Max. Width over Eaves	Distance, Rail to Eaves	Running Board		
						Width	Size of Matl.	Length
D. L. & W.	Pressed Steel U; also ∩	7	Inside and all Steel	9′ 7″	12′ 5½″	19″	1⅛″x6″	38′ 2¼″
C. R. R. of N. J.	Pressed Steel	7	Inside Metal	9′ 6¾″	12′ 2⅞″	19″	1″x6″	38′ 6″
P. & L. E.	Rolled Steel	11	All Steel	9′ 5½″	12′ 6½″	20″	1″x6″	38′ 3¼″
N. Y. O. & W.	Pressed Steel [	11	All Steel	9′ 6″	12′ 5½″	24″	1″x7½″	38′ 8″
P. & R.	Pressed Steel U	8	Inside Metal	9′ 10″	12′ 1¾″	19″	13/16″x5¾″	38′ 7″
B. & Albany	Pressed Steel [	8	Outside Metal	9′ 5 7/16″	12′ 7⅛″	20″	1″x6″	38′ 3″
C. & N. W.	⅜″x3″ Plate; 3″x3″ wood	12	Inside Metal	9′ 9″	12′ 5⅞″	18½″	1¼″x6″	41′ 10″
Un. Pac.	4″x2″x¼″ ∠; 1⅞″x9¾″ wood	9	Outside Metal	10′ 1″	13′ 4 3/16″	24″	1⅛″x7½″	42′ 5″
C. & O.	3″x3″x¼″ ∠ and wood	7	Outside Metal	9′ 7½″	12′ 4″	24″	1″x7½″	38′ 3⅝″
Erie	Pressed Steel [	8	Inside Metal	9′ 3⅛″	12′ 6 11/16″	19″	1¼″x6″	38′ 5½″
Can. Pac.	Pressed Steel [	8	Inside Metal	9′ 3½″	12′ 7 3/16″	24″	⅞″x7½″	38′ 5½″
Wabash	Pressed Steel ∩	11	All Steel	9′ 10½″	12′ 0½″	18¾″	⅞″x5¾″	38′ 7″
Frisco	4″—9½ lb. I	8	Outside Metal	9′ 7⅛″	12′ 5⅝″	18″	1⅛″x5¾″	42′ 1″
Un. Pac.	3″x3″x¼″ ∠, and wood	9	Outside Metal	9′ 8″	13′ 1 3/16″	24″	1⅛″x7½″	42′ 5″
P. R. R.	Pressed Steel U	10	⅛″ Steel Plate, riveted	9′ 11 11/16″	11′ 8″	18⅛″	1½″x5¾″	42′ 11½″

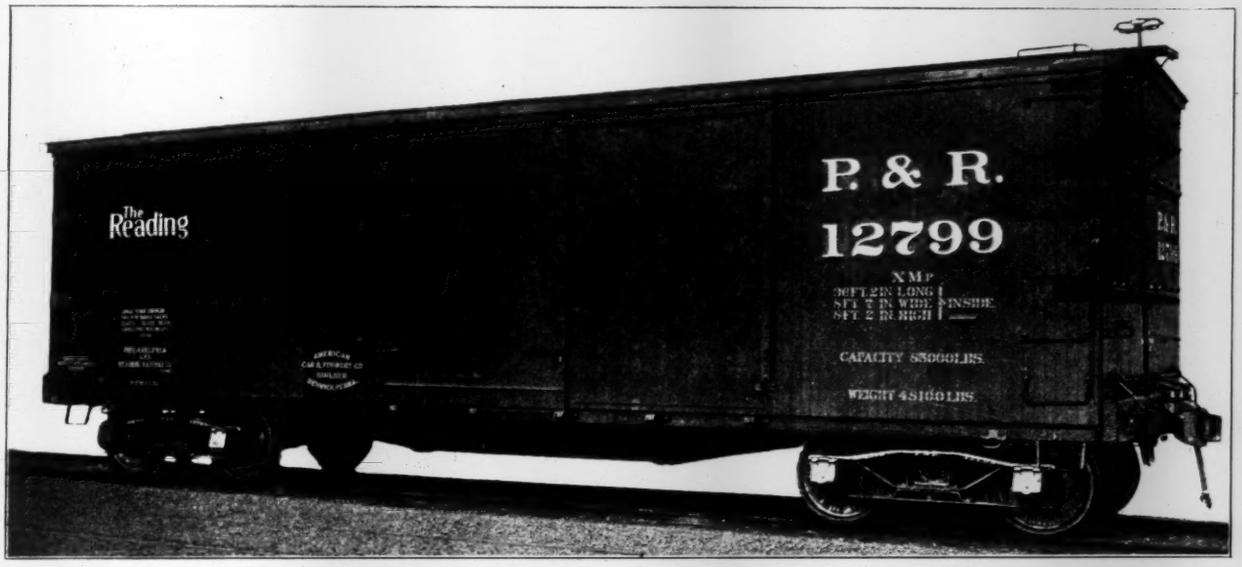


Fig. 12 40-Ton Steel Underframe Box Car used on P. & R. Ry.

low the roof boards. The outside roof boards are simply a protection to keep the trainmen from walking on the roofing sheets. The advantages of the inside type are: (*a*) flexibility, (*b*) protection of the metal from the weather, (*c*) protection of the metal from trainmen's boots, and (*d*) prevention of the quick corrosion of the metal, due to the roof boards preventing a deposit of cinders on the metal, which, when attacked by moisture, quickly eats away the galvanizing and also the sheet itself.

The objections raised against this type are that the outside roofing boards work loose, the torsional strains of the car causing the nails to work out and rust off. This condition is usually caused by the weaving of the car superstructure and can be eliminated to some extent by the use of stronger carlines. An inside roof properly applied as far as the metal is concerned, should last a good many years, with the replacement of the roof boards about every four years. These roof boards, besides being secured by nails, are now held down at the eaves by wire staples locking the boards to the facia.

Of the outside metal roofs, there are numerous types on the market, but in a general way they are similar. Their differences usually are in the method of fastening the sheets at the eaves. The gage of metal ranges in most cases from 22 to 26 U. S. The advantages claimed for the outside metal roofing are: (*a*) ease of application, (*b*) ease of repair, (*c*) somewhat lower first cost, and (*d*) possible prevention of fires, particularly in the west.

The objections which develop in this type of roof have been: the exposure of the metal itself to weather and chafing of the sheets where joined, causing the galvanizing to wear off so that the sheet quickly rusts. Cinders also collect along the eaves where castings are used, and when wet, sulphuric acid action will set in and eat out the sheet. This is partially overcome by the use of a slip joint along the eaves as provided for on the later types.

The all-steel type of roof is a development of the last three or four years, and consists of metal plates of about 16 U. S. gage resting on steel carlines, they being an integral part of the roof. In some cases the sheets extend from side to side of the car, and in others

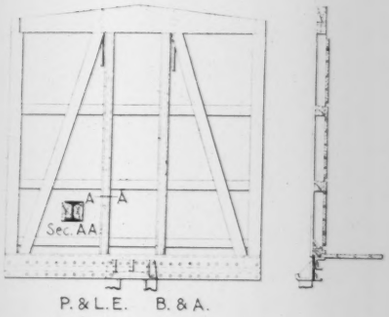


Fig. 13 End Framing used on P. & L. E. and B. & A. Cars showing I-Beam End Posts with Wood Fillers and Diagonal Braces Extending from End Sill to End Plate at Center Posts

the sheets are divided extending from the eaves to the ridge pole. The amount of galvanizing used on these sheets is practically the same as that on the outside metal roofs, which is about 1.8 oz. per sq. ft. on both sides of the sheet. The claim is made that this type somewhat lightens the weight of the car, but the same objections have been raised regarding the wearing out of the material as well as the tearing of the metal due to its rigid application. This latter feature is now receiving some attention by the manufacturers, and no doubt can be overcome. This style of roof is more expensive than the other types previously mentioned.

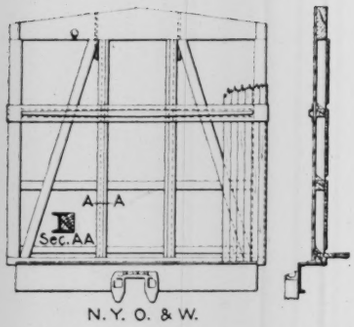


Fig. 14 End Framing used on N. Y. O. & W. Car having I-Beam End Posts with Wood Fillers; Diagonal Braces Extending from End Sill to End Plate at Center Posts and One Pressed Steel Horizontal Brace

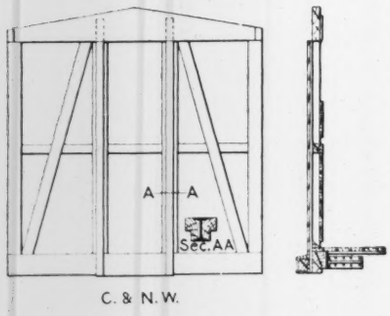


Fig. 15 End Framing used on C. & N. W. Car with I-Beam End Posts having Wood Fillers; Diagonal Braces extend from Sill to End Plate at Center Posts

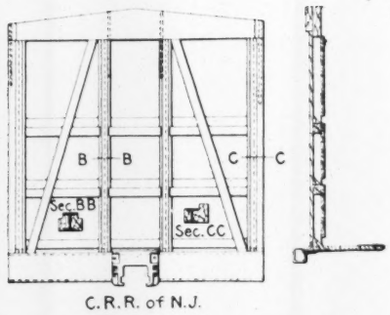


Fig. 16 End Framing used on C. R. R. of N. J. Car having I-Beam Center and Corner Posts with Wood Fillers; Diagonal Braces extend from End Sill to End Plate at Center Posts

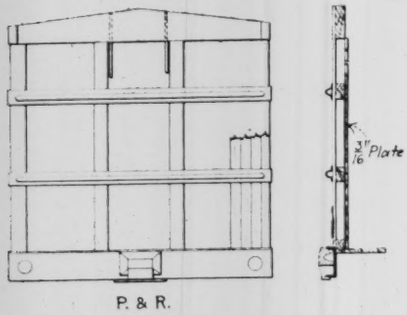


Fig. 17 End Framing used on P. & R. Car with Wood Center Posts; Plate Reinforcement and 3/16-inch End Surfacing Plate; Two Pressed Steel Horizontal Braces

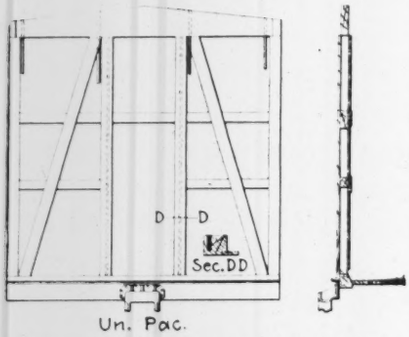


Fig. 18 End Framing used on Un. Pac. Car with Center Posts consisting of Wood and Plate Reinforcement; Diagonal Braces extending from End Sill to End Plate at Center Posts

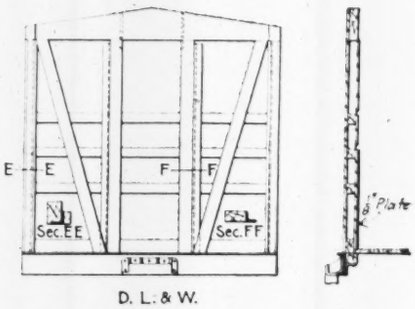


Fig. 19 End Framing used on D. L. & W. Car showing Center and Corner Posts made up of Angle Iron and Wood Fillers; Diagonal Braces run from End Sill at Center Posts to End Plate at Corner Posts 1/4-In. End Reinforcing Plate

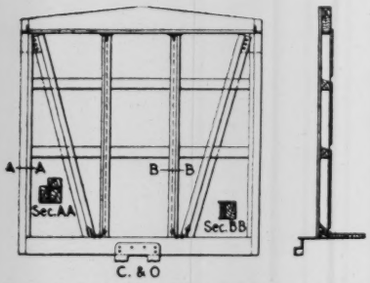


Fig. 20 Steel End Framing used on C. & O. Car with I-Beam Center Posts; Diagonal Braces run from End Sill at Center Posts to End Plate

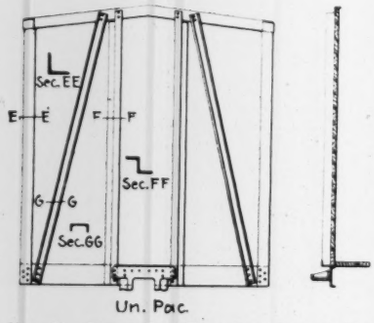


Fig. 21 Steel End Framing used on Un. Pac. Car with Z-Bar Center Posts; Channel Braces run from End Sill to End Plate at Center Posts

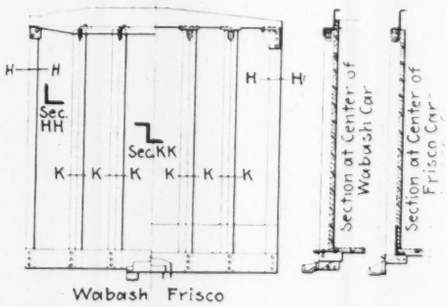


Fig. 22 Steel End Framing used on Wabash and Frisco Cars with Z-Bar Center and Intermediate Posts; no Diagonal Braces

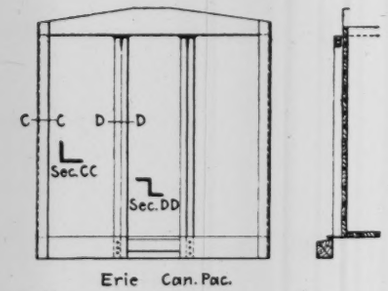


Fig. 23 Steel End Framing used on the Erie and Can. Pac. Cars with Z-Bar Center Posts; No Diagonal Braces

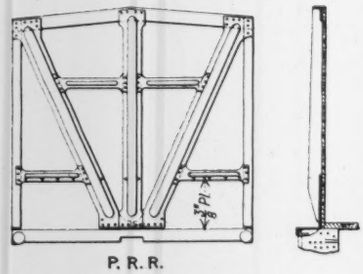


Fig. 24 Steel End Framing used on P. R. R. Car with Pressed Steel U-Sections; Diagonal Braces run from End Sill at Center Posts to End Plate and 3/8-In. End Reinforcing Plate at Bottom

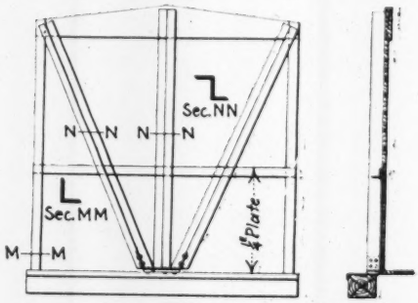


Fig. 25 Steel End Framing, M. C. B. Recommended Design with Single Z-Bar Center Post; Diagonal Braces run from End Sill at Center to End Plate and 1/4-In. End Reinforcing Plate at Bottom

Fig. 26 40-Ton Steel Underframe Box Car used on C. & N. W. Line

Large sums of money are paid out annually by our railroads to cover damage claims due to wet lading and the roof problem is a severe one with us. The service requirements, due to the use of heavy power and the severe service that cars are receiving in freight classification yards, compel us to give this matter our earnest attention and assist the manufacturers of car roofs as much as possible in developing a roof that, with ordinary care, will stay tight and protect the lading. Considerable success has been obtained with roofs applied to box cars made up of inside and outside roof boards, having a layer of waterproof roofing material between the boards, similar to that applied to refrigerator cars.

In the application of running boards, there seems to be no standard method followed. Table 8 shows that the width over all varies from 18 in. to 24 in. and size of material from 7/8 in. to 1½ in. thick and in widths from 5¾ in. to 7½ in. This does not appear on the surface to be a very important matter, but it seems to me that a better understanding should have existed between railroads, at least to arrive at a standard width of platform for the safety of trainmen and standard size of materials. The Interstate Commerce Commission recommends a standard width of 20 in. and allows a minimum of 18 in. I would suggest, therefore, that all railroads, when applying new running boards to old or new equipment, construct the platform 20 in. wide using 1⅛ in. by 6¼ in. material.

Table 9. This table shows the spread of body bolsters for box cars of different inside lengths, also distance over striking plates, truck wheel centers, etc. For cars 36 ft. inside length, bolster centers vary from 26 ft. 6 in. to 27 ft. 6 in. and for the longer car this variation is shown from 30 ft. 6 in. to 32 ft. 6 in. The effect of a long overhang of the car from the center

TABLE 9 DISTANCE BETWEEN BODY BOLSTERS, SPREAD OF TRUCK WHEELS, TYPE OF TRUCK FRAMES, BOLSTERS, ETC.

Road	Inside Length	Length over Striking Plate	Truck				
			Centers	Wheel Base	Type of Frame	Type of Bolster	Kind of Wheels
D. L. & W.	36′ 0″	37′ 7⅝″	27′ 0″	5′ 0″	Arch Bar	Cast Steel	Cast Iron
C. R. R. of N. J.	36′ 0″	38′ 3½″	27′ 0″	5′ 6″	Arch Bar	Cast Steel	Cast Iron
P. & L. E.	36′ 0″	38′ 0½″	27′ 0″	5′ 6″	Cast Steel	Steel Built up	Cast Iron
N. Y. O. & W.	36′ 0″	38′ 8⅞″	26′ 6″	5′ 6″	Cast Steel	Cast Steel	Cast Iron
P. & R.	36′ 2″	38′ 2½″	27′ 6″	5′ 6″	Arch Bar	Steel Built up	Cast Iron
B. & Albany	36′ 0″	38′ 1″	27′ 0″	5′ 6″	Cast Steel	Steel Built up	Cast Iron
C. & N. W.	40′ 0″	41′ 10⅞″	30′ 6″	5′ 0″	Arch Bar	Steel Built up	Cast Iron
Un. Pac.	39′ 11⅞″	42′ 1¼″	30′ 8″	5′ 6″	Cast Steel	Steel Built up	Cast Iron
C. & O.	36′ 0″	38′ 6½″	26′ 10″	5′ 6″	Arch Bar	Cast Steel	Cast Iron
Erie	36′ 0″	38′ 1¼″	26′ 10″	5′ 4″	Cast Steel	Steel Built up	Cast Iron
Can. Pac.	36′ 0″	38′ 1¼″	26′ 10″	5′ 4″	Arch Bar	Steel Built up	Cast Iron
Wabash	36′ 5⅝″	38′ 5⅝″	27′ 2″	5′ 4″	Arch Bar	Steel Built up	Cast Iron
Frisco	40′ 0″	42′ 0¾″	31′ 0″	5′ 6″	Cast Steel	Cast Steel	Cast Iron
Un. Pac.	40′ 5⅜″	42′ 1¼″	30′ 8″	5′ 6″	Cast Steel	Steel Built up	Cast Iron
P. R. R.	40′ 6″	42′ 6″	32′ 6″	5′ 6″	Arch Bar	Cast Steel	Rolled Steel

line of the bolster to the pulling face of the coupler has a tendency to cause derailment on curves, due to the coupler side clearance in the striking plate not being sufficient to permit the coupler to swing over when the car is coupled with another car that has a short overhang; if derailment does not occur, excessive wheel flange wear is produced. For 36 ft. box cars it would appear desirable to have the bolster centers made 27 ft. which is now standard on a large number of railroads and allows ample space for the application of draw gear.

For longer cars the same overhang as obtained under the above conditions for 36 ft. cars could be maintained, which would make the bolster centers 31 ft. for a car 40 ft. long inside. The distance from the face of the striking plate to the outside face of the body end construction should be ample to permit of the proper clearances being maintained for safety appliances, as required by law.

Truck wheel centers vary somewhat, the majority of the railroads now using trucks with wheels spaced 5 ft. 6 in. apart. This I consider very good practice, as it allows ample room for inside brake rigging. Truck arch bars and cast-steel side frames should be designed to interchange with one another and should conform to the Master Car Builders' requirements. The practice of using various designs of cast-steel side frames which vary in details should be discouraged, as there is no reason why a standard design of truck side frame for the different capacity cars should not be obtained and applied by every railroad in the country. This certainly would simplify repairs and they could then be purchased in the open market subject to specifications.

Bolster designs should also be made standard. This is a very important matter as the life of truck bolsters made of cast steel is uncertain, a number being replaced within five to ten years after cars are placed

TABLE 10 DIMENSIONS OF DRAFT SILLS, SIDE SILLS, FLOOR SUPPORTS, ETC

Road	Side Sills	Draft Sills	End Sill Diagonal Brace	Body Bolster			Cross Bearer				Floor Beams	
				Type	Plates		Type	Plates		Spacing Ctr. to Ctr.	Type	No.
					Top	Bottom		Top	Bottom			
D. L. & W.	8"—11¼ lb. [with 3"x3½"x 5/16" ∠ 3¾"x4⅜" wood	12"—25 lb. [	4"—8.2 lb. Z	Pressed Steel][	½"x20½"	⅜"x10"	Cast Steel	5/16"x7"	5/16"x6"	7' 0"	4"—8.2 lb. Z	3
C.R.R. of N.J.	12"—20½ lb. [3"x3½"x⅜"∠ 3¾"x4" wood	15"—33 lb. [	5"—6.5 lb. [	¼" Pressed Steel [s back to back	5/16"x17½"	5/16"x14"	¼" Pressed Steel [	⅜"x6"	⅜"x6"	9' 0"	6"—8 lb. [	3
N.Y.O.& W.	¼" Pressed Steel Z—9" high	⅜" Pressed Steel Z	5"—6.5 lb. [	¼" Pressed Steel][	⅜"x14"	½"x14"	¼" Pressed Steel [	¼"x6"	¼"x6"	8' 7"	¼" Pressed Steel [	3
P. & R.	10"—20 lb. [3"x3"x 5/16"∠ 3½"x4" wood	⅜" Pressed Steel Z spliced to ctr. sill	5"—9 lb. [	⅜" Pressed Steel [s back to back	½"x24"	¾"x16"	⅜" Pressed Steel [	½"x6"	⅜"x6"	9' 2"	5"—9 lb. [	3
B. & Albany	4"—8.2 lb. Z 4"x4" wood	⅜" Pressed Steel Z spliced to ctr. sill	5"x3"x 5/16" ∠	¼" Pressed Steel][	⅜"x15"	⅜"x15"	¼" Pressed Steel [	¼"x3½"	¼"x3¾"	9' 0"	Same as cross-bearer with cover Plates	3
C. & N. W.	6"—15.6 lb. Z	15"—33 lb. [	3½"x3½"x ⅜" ∠	¼" Pressed Steel][	⅜"x22½"	⅝"x15"	¼" Pressed Steel [	⅜"x5½"	⅜"x5½"	7' 8"	4"—9½ lb. I	8
Un. Pac.	5"—11.6 lb. Z with 3 13/16"x5½" wood	⅜" Pressed Steel spliced to ctr. sill	None	Cast Steel	.....	.....	10"—25 lb. I	.....	.....	9' 0"	10"—25 lb. I	3
C. & O.	8"—11¼ lb. [5½"x3" wood	15"—33 lb. [	¼" Pressed Steel [5" wide	¼" Pressed Steel][	½"x12"	⅝"x12"	¼" Pressed Steel [	⅜"x6"	⅜"x6"	6' 6"	4"—5¼ lb. [	3
Erie	8"—11¼ lb. [flanges in	15"—33 lb. [	5"x3½"x⅜"∠	¼" Pressed Steel][	½"x15"	½"x15"	¼" Pressed Steel [	½"x6"	½"x6"	5' 3½"	4"—8.2 lb. Z	4
Can. Pac.	8"—11¼ lb. [flanges in	15"—33 lb. [	5"x3½"x⅜"∠	¼" Pressed Steel][	½"x15"	½"x15"	¼" Pressed Steel [	½"x6"	½"x6"	5' 5½"	4"—8.2 lb. Z	4
Wabash	8"—11¼ lb. [flanges in	⅜" Pressed Steel Z spliced to ctr. sill	4"x3"x¼"∠	¼" Pressed Steel][	⅜"x15"	⅜"x15"	¼" Pressed Steel [	⅜"x6"	⅜"x6"	9' 0"	¼" Pressed Steel [	3
Frisco	5"x3"x⅜" ∠ 3"x4⅝" wood	⅜" Pressed Steel Z spliced to ctr. sills	5"—6½ lb. [	5/16" Pressed Steel][	⅜"x14½"	⅜"x18"	9"—15 lb. [	.....	.....	6' 5¾"	9"—15 lb. [	2
Un. Pac.	9"—13¼ lb. [flanges in	¼" Pressed Steel outside angle No splice	None	¼" Pressed Steel][	⅜"x14"	⅜"x14"	¼" Pressed Steel [	¼"x6"	¼"x6"	9' 0"	¼" Pressed Steel [	3
P. R. R.	6"x4"x⅜" ∠	⅜" Pressed Steel No splice	Pressed Steel [8" wide	⅜" Pressed Steel U Shape	.....	.....	⅜" Pressed Steel][	⅜"x12"	⅜"x12"	17' 10"	Pressed Steel [¾" deep	6

in service. It would avoid unnecessary delay in obtaining new bolsters for repairs when replacing a built-up design, especially when changing from one manufacturer to another, who not having a bolster pattern that will interchange, will try to furnish something else or make new patterns and in the meanwhile cars are tied up at the repair shops. It is manifestly impossible to carry such parts in stock for five to ten different designs for the same capacity car, as this cannot be done without increasing the amount of stock 25 to 50 per cent over the present allowance.

Tables 11 to 14. These tables have been compiled to show interesting information on the subject of center sill constructions for 14 different cars, the types of underframes used in which are shown in outline in Figs. 27, 28 and 31. The heavy lines in the drawings indicate the cover plates used which appear to be a general practice among designers. This is considered by many to be a very desirable feature and besides adding to the rigidity of the structure, increases the net area of section and therefore reduces the fiber stress to within reasonable figures.

The strains which an underframe has to withstand vary, and depend a great deal on the design and arrangement of body bolsters, side sills and body framing. With substantial side sills and body bolsters, compressive strains can be transmitted by the latter and thus part of the compressive load can be taken care of by the side sills. However, there is a limit to the load the side sills can take care of which is based on the ratio of length to the least radius of gyration, the length being considered as the maximum distance between adjacent floor beams. In the case of cars with wood body side framing it would appear desirable to provide sufficient area at the smallest section of the center sills to take care of end strains, allowing the side sill to carry only its proportions of the vertical loads due to lading, weight of superstructure and an allowance for oscillation.

In the case of box cars with steel side frames there is no question about the ability of the frame structure to carry considerably greater loads, both vertically and due to end shock, on account of the diagonal braces assisting in transmitting the strain throughout the side. For this reason some designers do not consider it necessary to use continuous cover plates on the center sills, but use rolled steel sections for these sills, having a much smaller net area than what is considered good practice by others.

In order to analyze properly the stresses in underframes a standard method of comparison should be made. Cars do not fail as a rule because of the weight of lading, but principally because of strains transmitted through the coupler. The magnitude of the end shocks that underframes have to withstand were investigated in tests conducted prior to 1902, on the

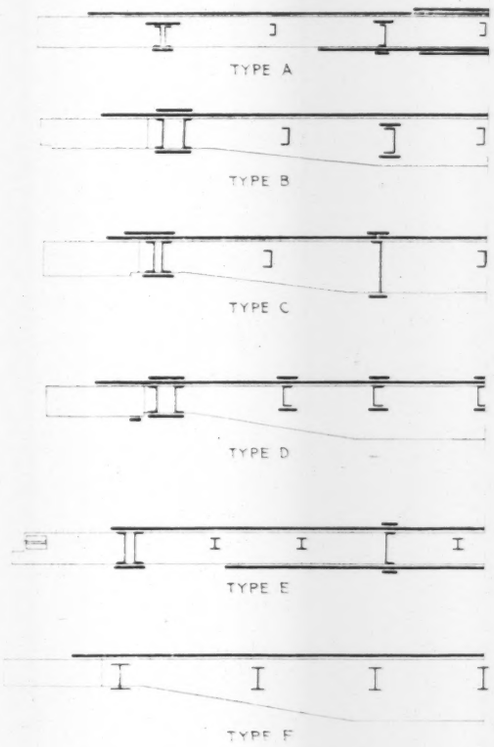


Fig. 27

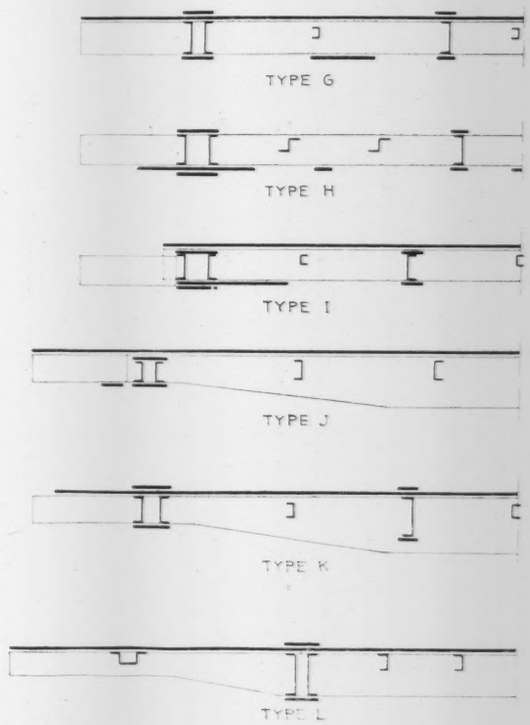


Fig. 28

Fig. 27 Types of Center Sills showing the Diversity in Design, Arrangement of Cross Bearers, Length of Cover Plates, Etc., as applied to Box Cars with Wood Side Frames

Fig. 28 Types of Center Sills showing the Diversity in Design, Arrangement of Cross Bearers, Length of Cover Plates, Etc., as applied to Box Cars with Steel Side Frames

TABLE 11 CARS WITH WOOD SIDE FRAMES AT CENTER

Road	Sill Type	Section Type	Depth over Flanges, In.	Web Plate, In.	Outside Top Angle, In.	Bottom Angle, In.		Cover Plate, In.		Min. Area, Sq. In.	Neutral Axes		Section Moduli		Max. Stress due to Vertical Loads, Lb. per Sq. In.	Compression due to End Shock, Lb. per Sq. In.	Compression due to Eccentricity, Lb. per Sq. In.	Maximum Combined Compression, Lb. per Sq. In.	Center Line of Draw Gear above or below Neutral Axis, In.	$\frac{1}{A}+\frac{e}{S}$
						Outside	Inside	Top	Bottom		N_c	N_t	S_c	S_t						
D. L. & W.	A	A	12	...	...	...	...	2–¼x19	2–¼x19	32.12	6.21	6.79	154.16	141.0	9851c	9338	6402	12787	3.29 below	0.054
C. R. R. of N. J.	A	A	15	...	...	...	...	1–⅝x20½ 1–¼x20½	1–⅝x20½ 1–¼x20½	36.23	7.67	8.20	209.55	196.0	10770t 7421c 7885t	8279	697	16401	.487 above	0.029
N. Y. O. & W.	B	G	24	¼	3⅞ fl'ge	3½x3x 5/16	3½x3x 5/16	¼x21¼	...	27.67	12.74	11.51	212.57	235.28	8462c 7645t	10842	2455	21759	1.74 above	0.044
P. & R.	C	E	26	⅜	4x4x½	4x4x½	4x4x½	¼x22½	...	45.01	13.06	13.19	377.69	373.97	5514c 5569t	6664	5012	17190	6.31 above	0.038
B. & A.	D	E	22	¼	3x3x⅜	3x3x⅜	3x3x⅜	¼x20¼	...	26.84	10.18	12.07	213.67	180.21	8931c 10590t	11177	3410	23519	2.43 above	0.048
C. & N. W.	E	B	15	...	...	...	...	⅜x20	⅜x20	33.12	7.51	8.24	188.57	171.86	11859c 13012t	9056	7143	13772	4.49 below	0.058
Un. Pac.	F	E	30½	¼	3x3x 5/16	3x2x⅜	3x3x 5/16	¼x20½	...	32.09	15.26	15.49	317.92	313.2	8566c 8694t	9346	5671	23583	6.01 above	0.049

Lake Shore & Michigan Southern Railway with a dynamometer car having nominal capacity in apparatus of 300,000 lb. It was found that the tensile and buffing strains, with an engine having a tractive power of 36,000 lb., were from 50,000 to 70,000 lb. and 80,000 to 150,000 lb. respectively, depending upon the skill of the engineer in manipulating the engine, the train remaining intact. In coupling an engine to its train, buffing strains from 65,000 to 142,000 lb. were obtained. Thirty cars moving at about 6½ miles per hour, and coupling on to ten loaded cars with brakes set, gave a shock of 376,492 lb. It would therefore appear from the above results, that provisions should be made in designing a steel underframe box car to take care of an impact blow of 350,000 lb. transmitted throughout all sills.

It would therefore seem advisable to assume an end strain of 200,000 lb. on the center sills of box cars with steel side frames and 300,000 lb. for box cars with wood side frames for the reasons previously mentioned. If the center line of coupler were directly on line with the neutral axis of the section to be analyzed, the stress per square inch on the center sills due to end shocks would be equal to the buffing force B divided by the area A of section. Referring to the data compiled in Tables 11 to 14 on center sills, the area of the sills is given both at the center line of the car and near the bolster. The eccentricity e or the distance from the center line of the draw gear to the neutral axis is also given for these sections. Stress at the bolster due to eccentricity equals $\frac{B_e}{S_t}$ when the center line of the draw gear is below the neutral axis, and $\frac{B_e}{S_c}$ when the center line is above the neutral axis. The combined stress at the bolster equals $\frac{B}{A}+\frac{B_e}{S_t}$ or $\frac{B}{A}+\frac{B_e}{S_c}$, depending upon the location of the center line of the draw gear. At the center line of the car, compression stress due to the lading equals $\frac{M}{S_c}$. Stress due to eccentricity equals $\frac{B_e}{S_c}$. Stress due to end shock equals $\frac{B}{A}$. When the center line of the draw gear at the center of the car is below the neutral axis, the combined stress equals $\frac{M}{S_c}+\frac{B}{A}-\frac{B_e}{S_c}$, and if the center line is

TABLE 12 CARS WITH STEEL SIDE FRAMES AT CENTER

Road	Sill Type	Section Type	Depth over Flanges, In.	Web Plate, In.	Outside Top Angle, In.	Bottom Angle, In.		Cover Plate, In.		Min. Area, In. Sq. In.	Neutral Axes		Section Moduli		Max. Stress due to Vertical Loads Lb. per Sq. In.	Compression due to End Stock, Lb. per Sq. In.	Compression due to Eccentricity, Lb. per Sq. In.	Maximum Combined Compression, Lb. per Sq. In.	Center Line of Draw Gear above or below Neutral Axis, In.	$\frac{1}{A}+\frac{e}{S}$
						Outside	Inside	Top	Bottom		N_c	N_t	c	S_t						
C. & O.	G	C	15	...	...	...	...	5/16x19¾	...	25.96	6.00	9.31	150.93	96.69	10972 c 17025 t	7704	7345	11337	5.56 below	0.095
Erie	H	D	15	...	...	...	...	...	...	18.73	7.092	7.908	80.0	71.72	20311 c 22655 t	10678	10275	20714	4.158 below	0.1112
Can. Pac.	H	D	15	...	...	...	...	...	...	18.73	7.092	7.908	80.0	71.72	20311 c 22655 t	10678	13270	17719	5.408 below	0.1287
Wabash	I	C	15	...	...	...	...	5/16x20	...	26.05	5.98	9.33	151.04	96.8	10887 c 16987 t	7677	6806	11758	5.14 below	0.091
Frisco	J	E	26	¼	3x3x¼	3x3x⅜	3x3x 5/16	¼x20	...	26.89	12.38	13.87	235.53	210.23	8725 c 9775 t	7437	747	16909	.88 above	0.04
U. P.	K	G	27¾	¼	3⅞ fl'ge	3½x3x⅜	3½x3x⅜	¼x23	...	28.78	13.94	14.06	261.67	259.43	9053 c 9131 t	6949	3829	19831	5.0 above	0.053
P. R. R.	L	H	20	⅜	4 fl'ge	4 fl'ge	4x4x 5/16	⅜x24	...	35.91	9.55	10.82	258.66	228.30	10600 c 12913 t	5569	2265	18434	2.93 above	0.038

TABLE 13 CARS WITH WOOD SIDE FRAMES AT BOLSTER

Road	Sill Type	Section Type	Depth over Flanges, In.	Web Plate, In.	Outside Top Angle, In.	Bottom Angle, In.		Cover Plate, In.		Min Area, Sq. In.	Neutral Axes		Section Modulii		Compression due to End Shock, Lb. per Sq. In.	Compression due to Eccentricity, Lb. per Sq. In.	Maximum Combined Compression, Lb. per Sq. In.	Center Line of Draw Gear below Neutral Axis, In.	$\frac{1}{A} + \frac{c}{S}$
						Outside	Inside	Top	Bottom		X_c	X_t	S_c	S_t					
D. L. & W.	A	B	12					$\frac{1}{4}$x19	$\frac{1}{4}$x19	21.30	6.25	6.25	103.11	103.11	12396	8728	21124	3.00 below	0.07
C. R. R. of N. J.	A	C	15					$\frac{1}{4}$x20$\frac{1}{2}$		24.91	6.33	8.12	134.27	95.28	12547	2109	14656	0.97 below	0.048
N. Y. O. & W.	B	G	15	$\frac{1}{4}$	3", fl'ge	3$\frac{1}{2}$x3x$\frac{5}{16}$	3$\frac{1}{2}$x3x$\frac{5}{16}$	$\frac{1}{4}$x21$\frac{1}{4}$		25.00	8.42	6.83	119.84	147.76	12000	5238	17238	2.58 below	0.057
P. & R.	C	E	11$\frac{1}{4}$	$\frac{3}{8}$	4x4x$\frac{1}{2}$	4x4x$\frac{1}{2}$	4x4x$\frac{1}{2}$	$\frac{1}{4}$x22$\frac{1}{2}$		36.18	5.91	5.59	123.53	130.60	8291	1929	10220	0.84 below	0.033
B. & A.	D	E	12$\frac{7}{8}$	$\frac{1}{4}$	3x3x$\frac{3}{8}$	3x3x$\frac{3}{8}$	3x3x$\frac{3}{8}$	$\frac{1}{4}$x20$\frac{1}{4}$		23.90	6.18	6.84	110.31	101.15	12552	4331	16883	1.46 below	0.055
C. & N. W.	E	C	15					$\frac{3}{8}$x20		27.30	5.76	9.01	164.24	98.47	10989	18686	29675	6.23 below	0.099
Un. Pac.	F	F	12$\frac{7}{8}$	$\frac{1}{4}$	3x3x$\frac{5}{16}$	3x3x$\frac{3}{8}$		$\frac{1}{4}$x20$\frac{1}{2}$		19.08	5.11	8.01	97.01	62.33	15719	19901	35620	4.55 below	0.118

above, the combined stress equals $\frac{M}{S_c} + \frac{B}{A} + \frac{B_c}{S_c}$. The ratio of stress to end strain is obtained by the formula $\frac{1}{A} + \frac{c}{S}$, in which S represents the section modulus, S_c to be used if the center line of the draw gear is below, and S_t if above, the neutral axis. The Car Construction Committee of the Master Car Builders' Association recommend that the above ratio on new cars should not exceed 0.06. They also recommend a minimum area of 24 sq. in. of center sills.

Tables 11 and 12 give the maximum stress on center sills due to vertical loading which was obtained by assuming a uniform load distributed throughout the sill. Calculations are based on the weight of car body, A, the lading, B, and the oscillation, C. The car body, weight A, carried on center sills was taken at 20,000 lb. except for Philadelphia & Reading box car, in which the weight used was 24,000 lb. (assuming as two-thirds total weight of car body and underframe). The lading B for 60,000 lb. capacity cars was assumed as 66,000 lb., for 80,000 lb. capacity cars was assumed as 88,000 lb. and for 100,000 lb. capacity cars was assumed as 110,000 lb. The oscillation C was taken at 20 per cent of the total sum of lading and weight of car body carried.

The calculations for center sill load for box cars with wood side frames were made as follows: load per square inch of floor space

$$w = \frac{A + B + C}{lm}$$

Total uniform load on center sills

$$W = wl\,(x + y)$$

where

l = length over centers of end posts, in inches
m = distance over centers of side posts, in inches
x = spacing of center sills
y = distance from back of center sill to center of side post, in inches (see Figs. 29 and 30).

The calculations for center sill load for box cars with steel side frames were made as follows: load per square inch of floor space

$$w_1 = \frac{\frac{A}{3} + B + C}{lm}$$

Total uniform load on center sills

$$W = w_1 l\,(x + y)$$

Bending moment of center sills

$$M = \frac{W}{2}\left(\frac{l}{4} - c\right)$$

where

M = maximum bending moment at center of car

TABLE 14 CARS WITH STEEL SIDE FRAMES AT BOLSTER

Road	Sill Type	Section Type	Depth over Flanges, In.	Web Plate, In.	Outside Top Angle, In.	Bottom Angle, In.		Cover Plate, In.		Min Area, Sq. In.	Neutral Axes		Section Modulii		Compression due to End Shock, Lb. per Sq. In.	Compression due to Eccentricity, Lb. per Sq. In.	Maximum Combined Compression, Lb. per Sq. In.	Center Line of Draw Gear above or below Neutral Axis, In.	$\frac{1}{A} + \frac{c}{S}$
						Outside	Inside	Top	Bottom		X_c	X_t	S_c	S_t					
C. & O.	G	C	15					$\frac{5}{16}$x13$\frac{3}{4}$		25.96	6.00	9.31	150.03	96.69	7704	11500	19204	5.56 below	0.095
Erie	H	D	15							19.8	7.5	7.5	83.4	83.4	10101	8993	19094	3.75 below	0.095
Can. Pac.	H	D	15							19.8	7.5	7.5	83.4	83.4	10101	11990	22091	5.0 below	0.110
Wabash	I	C	15					$\frac{5}{16}$x20		26.05	5.98	9.33	151.04	96.8	7677	10620	18297	5.14 below	0.091
Frisco	J	H	13$\frac{7}{8}$	$\frac{1}{4}$	3x3x$\frac{1}{4}$	3x3x$\frac{3}{8}$	3x3x$\frac{5}{16}$	$\frac{1}{4}$x20		22.34	6.93	7.19	108.01	104.1	8953	8760	17713	4.56 below	0.088
Un. Pac.	K	G	13	$\frac{1}{4}$	3$\frac{1}{2}$ fl.	3$\frac{1}{2}$x3x$\frac{3}{8}$	3$\frac{1}{2}$x3x$\frac{3}{8}$	$\frac{1}{4}$x23		23.03	6.86	6.39	103.54	111.16	8684	4174	12858	2.32 below	0.063
P. R. R.	L	H	11	$\frac{3}{8}$	4 fl.	4 fl.	4x4x$\frac{5}{16}$	$\frac{3}{8}$x24		30.68	5.38	5.99	125.62	112.83	6517	2198	8715	1.24 below	0.043

c = distance from center line of bolster to center of end post, in inches

$\frac{M}{S_c}$ = compression per square inch

$\frac{M}{S_t}$ = tension per square inch

Bending moment at any point x

$$M_x = \frac{W}{2}\left(x - c\right) - \frac{Px^2}{2}$$

where

x = distance in inches from center of end post to any section between bolster and center of car

P = load per lineal inch of sill

In calculating the Pennsylvania Railroad box car, it was assumed that the cross bearers transmitted to the center sills a certain proportion of weight of the car

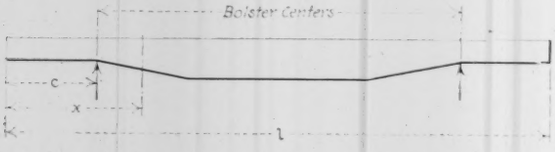


Fig. 29 Diagram for Determining Bending Moments

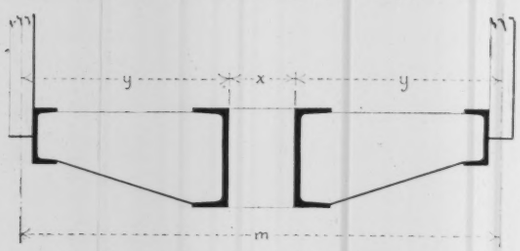


Fig. 30 Diagram for Load Distribution

body, thus producing an additional bending moment in the center sills.

From Tables 11 to 14 are obtained the data presented in Table 15. For the 36 ft. cars with wood body framing, it would appear that the averages shown for the area and stress both at the bolster and the center of the car approach figures which are safe for general practice. For the 36 ft. cars with steel body framing, the average stress per square inch behind bolster is too high for safe practice and should be reduced by increasing the area. The low combined stress at center of car is due to the center line of coupler being located about 5 inches below neutral axis, which reduces the compression due to direct end shock. At the center of car the stress due to lading alone is also too high for safe operation. For the 40 ft. cars with wood body framing, the average stress per square inch is entirely too high and should be reduced by increasing the area of the section and cutting down the eccentric load due to end shock; this also applies to the section at the center of the car. In the 40 ft. cars with steel body framing, the maximum combined stress at the center of the car is a trifle high.

TABLE 15 DATA COMPILED ON AREAS AND STRESSES IN CENTER SILLS

Area of Center Sills

	At Center			At Bolster		
	Min.	Max.	Aver.	Min.	Max.	Aver.
36-ft. cars, wood frame. . .	26.84	45.01	33.37	23.90	36.18	26.64
36-ft. cars, steel frame.....	18.73	26.05	22.19	19.80	26.05	22.72
40-ft. cars, wood frame. . . .	32.09	33.125	32.60	19.08	27.30	23.19
40-ft. cars, steel frame.....	26.89	35.91	30.52	22.34	30.68	25.35

Maximum Combined Stress

	At Center			At Bolster		
	Min.	Max.	Aver.	Min.	Max.	Aver.
36-ft. cars, wood frame.....	12505	23514	18274	10202	21124	16020
36-ft. cars, steel frame.....	10539	20714	15182	18297	23069	20409
40-ft. cars, wood frame.....	15607	23583	19595	29975	35620	32798
40-ft cars, steel frame.....	16909	19831	18393	8707	17713	13093

In all of these cases it is well to note that the relation of the center line of the coupler to the neutral axis has an important bearing on the strength of the sills. At the center of a car with fish-belly type sills

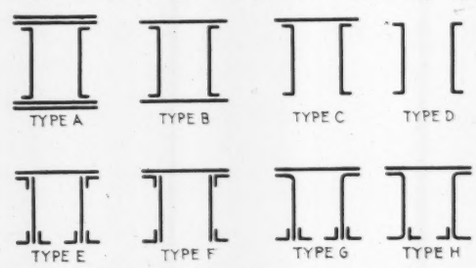


Fig. 31 Typical Sections of Center Sills showing Lack of Standardization

the center line of the coupler is usually above the neutral axis, which adds to the total combined compression; whereas, with rolled steel sills, the coupler center line being below the neutral axis, will counteract somewhat the compression due to impact blow. This leads me to believe that nothing is gained by making the depth of fish-belly sills at the center any greater than is required to take care of the vertical loads. It will also appear that a fish-belly type sill is necessary for all types of cars mentioned of 80,000 and 100,000 lb. capacity, except 36 ft. steel side frame cars, which will render good service when using a center sill construction of plates and channels.

Table 10. This table shows the general practice in designing body bolsters, cross bearers, side sills, and draft sills. For body bolsters, it is general practice to use two pressed steel channels spaced at various distances apart with cover plates top and bottom. The best designs have a spacing 6 in. to 8 in. between webs. For cross bearers, a variety of designs exist, the later

types consisting of heavy I-beams passing directly through the center sill web plate and extending the width of the car between side sills. This plan is also followed out on the intermediate floor beams and makes a neat and substantial arrangement. The general practice is to use a pressed steel channel with top and bottom cover plate.

For draft sills, the practice is, where structural steel channels are used for center sills, to extend the same channel to the end sill to serve as draft sills. It has been customary when fish-belly type center sills are used, to provide a pressed steel Z-shape draft sill and splice to center sill web plate projecting through the bolster. There is a tendency on the part of designers today to do away with the splice by extending the web plates of center sills and providing outside angles to form the draft sill, using a continuous cover plate. Where pressed steel center sills and cover plates are used, the practice has been followed of extending this construction to the end sill, extending the cover plate too near the end of the sill. This construction requires the use of web plates about 5/16 in. thick, so as to provide sufficient bearing area for draft lug rivets. I believe when draft sills have sufficient net area behind the bolster stop, that considerations of economical construction would warrant dispensing with the splice, as in view of the additional cost of a splice on 1000 cars, the expense of its application is not warranted when considering the number of sill failures likely to occur due to its omission.

As to draft gears, data regarding the type used have not been tabulated. It is sufficient to say that of the cars enumerated, six were equipped with spring draft gears and nine with friction gears. The impact blow resulting from cars coming together is practically absorbed by the draft gear. Friction gears are more efficient in this respect, absorbing a much greater percentage of total energy as compared with spring gears. This subject was thoroughly discussed by the members of the Master Car Builders' Association some years ago, a full account of which appears in their proceedings. Owing to the large variety of gears in service, necessitating numerous designs of draft lugs, key attachments, etc., it would appear that, if a standard arrangement of draft gear and all appliances connected therewith were adopted by all railroads, it would result in great economy of maintenance. This should include striking plates and carry irons, which on a large number of cars are not of sufficient strength due to arrangement of end sills.

The stresses in steel body framing can be obtained by graphical as well as analytical methods. Fig. 32 indicates the manner in which the stress diagram for vertical loads is obtained, a uniform load of 70 lb. to the lineal inch having been considered, corresponding to a uniform load of approximately 30,000 lb. for a 36 ft. car. The light lines indicate tension and the heavy lines, compression. The side sill and top plate at the door opening are subjected to the same stress, but it is the usual practice to provide more area in the side sill to take care of unsymmetrical loading. The posts and braces must also resist crossbending stresses due to pressure of lading. The bending moment due to this cause is

$$M = \frac{H^3 \tan^2 \theta D W}{18 \times 1728}$$

H = height of load in inches
D = one-half distance between posts in inches
W = weight of lading in pounds per cubic foot
$\theta = \frac{1}{2}$ (90 deg.—angle of repose).

By examining the tables shown giving the comparative data of various items which enter into the construction of a box car, it is surprising that more has not been done in the way of standard construction. The large expenses which railroads are now compelled to face due to repairs of freight cars could be partially reduced if standard designs were in use throughout the country. Repairs would be facilitated due to the use of standard materials throughout for various types of cars, fewer cars would be held up at car repair shops awaiting material from foreign roads, and interchange of cars would not be a hardship to any railroad, as all cars would be of equal strength. Also drawing room expenses would be reduced both for the railroad and car builder, and repair parts could be produced by cheaper methods than as followed out at present, due to elimination of a variety of designs and shapes, principally castings and pressed steel parts.

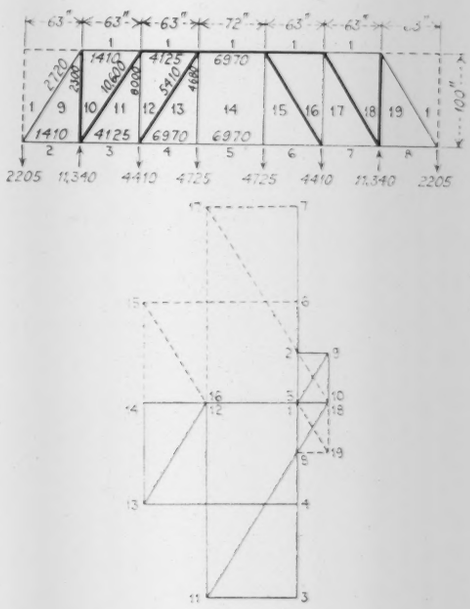


FIG. 32 GRAPHICAL METHOD OF DETERMINING STRESSES IN THE MEMBERS OF STEEL SIDE FRAMES

STEEL UPPER FRAME BOX CARS

By R. W. Burnett,[1] Montreal

Non-Member

The paper which is confined solely to superstructure details of the steel frame box car is intended to apply in general to steel frame practice as developed in connection therewith. While the early development of steel upper framing is passed over rather briefly, many of the important considerations that have influenced its adoption are discussed in detail, particularly as viewed by the Canadian Pacific Railway. The information and data presented are based on the writer's experience in this railway system in connection with the design, construction and maintenance of 30,000 cars of this type, which represent an investment of $30,000,000.

Credit is due to Mr. C. A. Seley, mechanical engineer of the Rock Island Lines, for designing the first outside sheathed steel superstructure box cars that were constructed in large numbers. The introduction of steel into the superstructure of the box car and the development of the outside sheathed steel superstructure in particular, were discussed so thoroughly by Mr. Seley in his comprehensive paper[2] before the Franklin Institute in January 1910, that I have thought it unnecessary to go over this same ground, but will review only briefly the development of the box car from the all-wood car through the intermediate stages of steel underframe cars.

The original wooden car, with the single spring draft rigging having the check castings bolted to the sills, gave little if any more trouble than modern equipment, due principally to the shorter trains, lesser density of traffic and to the use of link and pin couplers which compelled gentler handling of trains than is prevalent today. The steel underframe car was built mainly to secure a stronger center construction for the attachment of draft rigging and to get away from the trouble caused by wooden sills breaking and splitting, broken draft bolts, etc.

Fig. 1 First Inside Sheathed Steel Frame Car built by the Canadian Pacific Railway

While having many advantages over the old wooden car, the steel underframe car developed some troubles peculiar to itself, the most important being due to the fact that the body being carried on a rigid frame and not held together by the strains resulting from its weight, as in the old trussed cars, has a tendency to develop slack in the superstructure. This in turn affects the roof and sheathing. One principal trouble with outside sheathed cars is that, after they have been in service a comparatively short time, the sheathing frequently loosens at the end sill and at the side sills near the bolsters with resultant leakage of grain.

There were some steel frame box cars built previous to 1909, but the writer has been able to secure data on only the outside sheathed types. Of these 2700

[1] General Master Car Builder, Canadian Pacific Railway Company

[2] Vol. 169, No. 4, April, 1910, p. 278

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were in service on the Norfolk & Western, of which the first 100 were built in 1902; the owners advise they were satisfactory and the same type has been purchased on subsequent orders. The Rock Island and Frisco lines had in service at that date approximately 5000 cars similar to the Norfolk & Western and these also appear to have given satisfaction as the owners have reordered the same type several times. All of these, however, were outside sheathed and as regards leakage at the sills, had comparatively little advantage over the wooden cars. Recently both of these lines have purchased some inside sheathed cars. The Frisco car of this type is fully described in The Railway Age Gazette, October 3, 1913.

In 1908 the Canadian Pacific Railway designed the steel frame inside sheathed box car as shown in Fig. 1. This car avoided the disadvantage of the outside sheathed car which had not been accomplished by the steel frame cars constructed up to that time, and at once obtained a further reduction in weight and provided for cheapness of maintenance by the use of steel superstructure, without the additional lumber required by the outside sheathed car. With practically no preliminary experimenting 500 of these cars were built and since over 30,000 have been built similar to the first cars, with the exception of several refinements of details, such as corner and door posts, end doors and side plates, and joining of flooring and lining. These changes have not affected the general design of the car, but are improvements that have been introduced from time to time to reduce weight and simplify the construction. The latest type of car is shown in Figs. 3 to 5.

The steel frame outside sheathed car has several advantages over the types previously used, notably in that the tare ton weight is low in proportion to the capacity. There is such a variation in the figures used for the cost of hauling per ton-mile, that no attempt is made to say what the saving would amount to, but certainly the advantage of having a car equal, if not superior to other cars in all respects, weighing from 1000 to 5000 lb. less will appeal to all traffic and operating men. Not only is there that much less dead weight to haul when the car is empty or partly loaded but additional lading can frequently be carried. The actual limit on the paying load that can be carried in a properly designed car is the total weight on the axles. Thus, a car having 5 in. by 9 in. axles with such a tare weight that, when deducted from the capacity of the axles, allows the car to be safely loaded to 88,000 lb. could, if dead weight be reduced by 3000 lb., safely carry a paying load of 91,000 lb. and retain the same strength. Thus the actual capacity of the car is increased almost 4 per cent with a better ratio of paying to dead load.

Fig. 2 Type of Inside Sheathed Steel Frame Car used by the Rock Island System (40 Ft., 40 Ton)

With the wooden superstructure, it had been thought necessary to assist the superstructure by heavy roof construction, some going so far as to use different methods of diagonal bracing, but with the steel car it has been found that there is no appreciable local movement of the framing in the heaviest service which makes a simple proposition of the roof as it has only to take care of itself. This presents a simpler problem to roof designers, making it possible to design a roof much lighter, without necessity for use of purlins or ridge poles to strengthen the car. It is obvious that unnecessary weight in the roof raises the center of gravity, and increases the tare weight and cost and has other disadvantages.

In explanation of the local movement of this style of framing, it is well to mention tests we have made in jacking up this car, which demonstrated that the car would take a gentle twist from end to end, allowing the bolsters to be slightly out of the same plane hori-

zontally. This twisting was accomplished without any perceptible local distortion of the sides or ends. The capacity for twisting is a condition to be desired as it allows a car to adjust itself to uneven track conditions.

the opening where the posts and braces meet at the bottom becoming obstructed, resulting in grain being retained between the sheathing and lining with resultant complaints from shippers. All of this is overcome by the clean joining of the lining and the floor in the

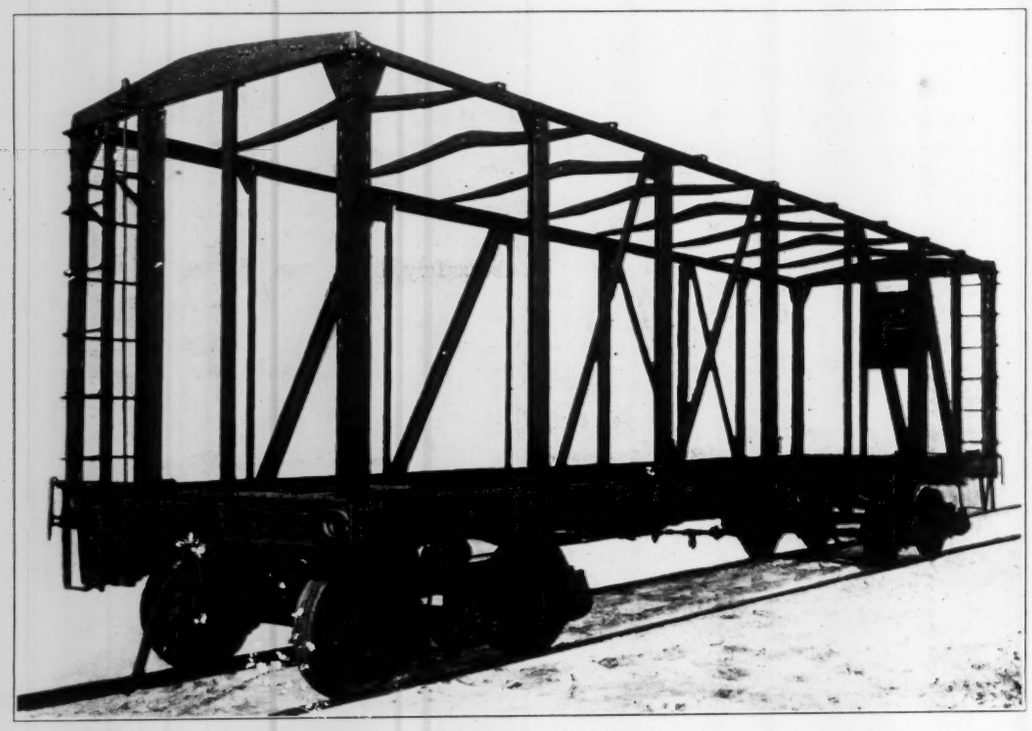

Fig. 3 Steel Frame of Canadian Pacific Railway Box Car Ready for Lining

In addition to being 5½ in. narrower than the outside of the sheathing of a wooden car, the superstructure of the Canadian Pacific Railway car is protected by the framing, so that a side swipe that would do serious damage to an outside sheathed car frequently does not touch the lining and is resisted by the framing without damage to the posts or braces. Frequently it is found that a side swipe that would almost demolish the sides of a wooden car only bends the steel framing, and in making repairs, the lining is merely removed, posts and braces straightened and the original lining replaced, the whole cost being the comparatively small labor charge. Jacking frames are being installed at all of our principal repair points for all classes of steel cars, and while not original with the Canadian Pacific Railway, have been amplified better to take care of steel frame box cars. With these frames, many jobs that would require the car to be cut apart, taking several days, can be done in a few hours without cutting rivets. With modern steel frame cars, these jacking frames are as much a necessity as the blacksmith shop or any other part of the shop.

With the outside sheathed car, it is difficult to clean a car properly when it is unloaded, on account of grain lodging between the framework and also on account of

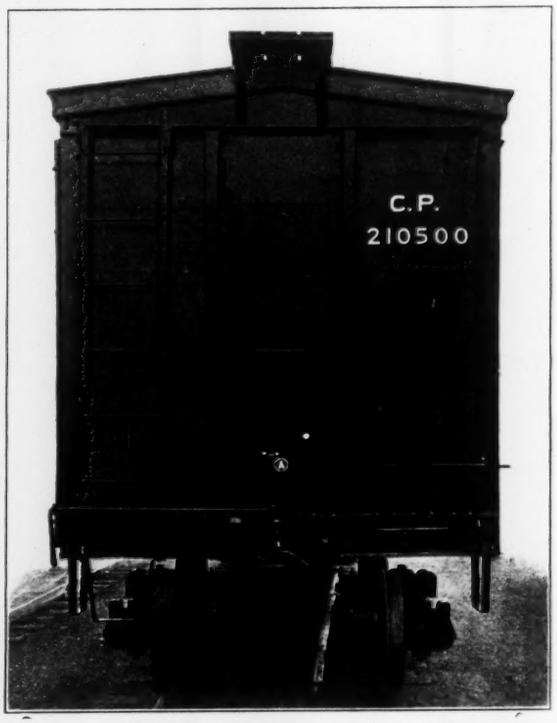

Fig. 4 End View of Canadian Pacific Inside Sheathed Car showing Grain-Tight End Doors

steel frame cars, and it is believed a change of this kind would have come years sooner if designers had kept in close touch with service conditions. One advantage of the steel frame car is that outside of possible repairs due to wreck damage and to wear and tear of couplers, wheels, brake shoes and journal bearings, the car does not deteriorate more rapidly in service than when stored.

Fig. 5 View of one of the Latest Inside Sheathed Cars built by the Canadian Pacific Railway (36 Ft., 40 Ton)

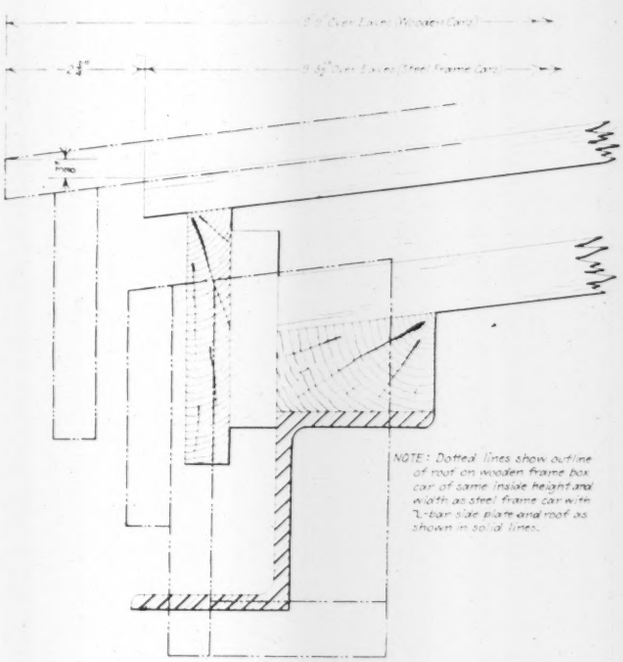

Fig. 6 Detail of Roof Clearances on Steel Frame and Wooden Box Cars

The grading of lumber for use in these cars is an item that has received much consideration. Yellow pine or fir has so far been the principal lumber used, although we have experimented to some extent with spruce. Spruce has the advantage of being lighter, but it seems to be more difficult to dry it sufficiently for this purpose. Great pains have been taken to avoid knots that are too large or numerous and while it is generally desirable to have lumber as free from knots as possible, I have never in the inspection of many hundreds of cars, seen where a knot had fallen out. It is, however, desirable to have lumber as free from sap and shakes as possible and thoroughly dry.

When the first of these cars were built outside of the Canadian Pacific Railway shops we had considerable difficulty in getting the lumber properly dried due to lack of both experience and facilities on the part of the car companies. We have about 3000 cars on which the lumber has shrunk and given them a bad appearance, but this result was expected, as when the cars were built the lumber was quite green. The sheathing of these cars could be tightened for less than $4 per car, but very few have been tightened owing to receipt of practically no reports of loss or damage to lading due to the shrinkage; also as they do not fre-

REPORT OF MOISTURE IN LUMBER FOR LINING BOX CARS

Built by ..... At .....

C. P. R. Equip. Order No. ..... For ..... Number of Cars .....

Report No. .....

Moisture determination strictly in accordance with C. P. R. Spec. No. 243 C.

Samples obtained every other day during construction, with a minimum of one sample for each one hundred cars built. Result of each test must be promptly recorded on this sheet and sent to R. W. Burnett, Gen'l M. C. B., Montreal.

Lab. No.	Date of Sample	Cars Completed	Car Nos. Represented	Moisture Per Cent	Average To Date	Orig. Width Inches	Shrinkage Inches	Average To Date Inches	REMARKS

Signed ..... Engineer of Tests.

Fig. 7 Form used for Reports to Canadian Pacific Railway on Moisture Determinations on Lumber

quently reach our main repair tracks, being shopped only for such repairs as wheels, or wreck damage, we have not considered it advisable to shop the cars for a defect which is almost entirely a matter of appearance. The lining shrinks as much in two months of summer weather, as it ever will.

The lining should not be matched before drying, as it warps and curls rendering it difficult to make a tight joint. The rough size of lumber should be at least $\frac{1}{4}$ in. greater than finished dimensions. In establishing limits for drying lumber no information or data could be secured whatever, and after experimenting we came to the conclusion that a piece of this lining of full cross-section subjected to a temperature averaging 170 deg. fahr. for 96 hours should not lose more than 6 per cent in weight and that lumber represented by samples losing more than 10 per cent must not be used until further dried.

The variable condition of the lumber when taken from the yard makes it necessary to use careful judgment as to the length of time it should be kept in the kiln. At the Angus shops of the Canadian Pacific Railway this responsibility falls on the wood-mill foreman whose constant attention to this feature makes him the best fitted for the purpose. The average moisture loss reported by the test department for lumber used on cars now building at the Angus shops is 5.25 per cent which shows that we are getting very satisfactory results from the kilns. A number of tests were made last year on lumber taken from the yard. These tests showed a moisture loss of between 25 and 30 per cent which shows the importance of drying

Fig. 8 View of Standard Canadian Pacific Steel Frame Car fitted with Corrugated Steel Lining

lumber properly. The form shown in Fig. 7 is used for reporting results of tests both at Angus and outside shops.

Due largely to our insistence, nearly all the car plants in the country are now equipped with dry kilns, and any possible additional cost of drying lumber in excess of what has been considered good practice in the past would be less than $1 per car. Such drying would make the car side practically the same as one board so that it is absurd that the possible shrinkage of lumber should be considered as any reason for this type of car not being built. It has been claimed that lumber can be so dried that it will swell and bulge, but we have never found this to occur. We have had

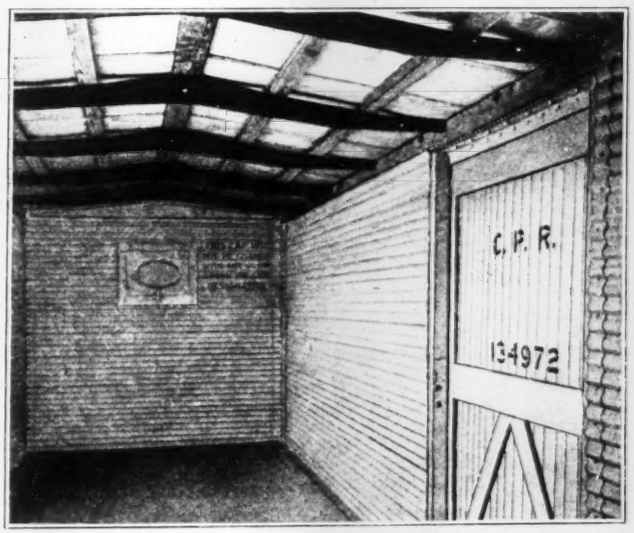

Fig. 9 Interior of Canadian Pacific Steel Frame Car with Corrugated Steel Lining

cases where lumber slightly moist has dried more rapidly on the inside, due to that side not being painted, and made the outside of the boards slightly convex, with tight joints that could be easily mistaken for swelling, whereas the opposite is the case. We have kept a car with very green lumber in the passenger shop with a high temperature for over a month until the lumber was absolutely bone dry, and then put it outside with doors open through four weeks of constant raining spring weather, with the result that there was no closing of the cracks that could be detected which further proves that there is nothing to be feared from lumber being too dry.

The defects in the sheathing that must be most closely watched are shakes or splits that extend obliquely downward into the car which must be knifed in with paste before the car is painted. The edges of the lining should be painted, and we have found this can be done more easily and thoroughly by dipping the boards and putting them through between two rubber scrapers which removes the surplus paint leaving the edge thoroughly coated. This gives a thin coat of paint on the inside of the car which is an advantage in causing the lumber to dry more uniformly and diminishes the tendency to warp. Narrow boards have the advantage of having less tendency to warp, and also if the lumber should not be thoroughly dry, there is less total shrinkage for each board making the space between the edges narrower. The steel work and roofing are painted the same as other cars. This considerable space has been given to the grading and drying, and painting of lumber, as we have found that these factors have required much more attention than everything else combined in connection with the car.

The development of the inside sheathed car has been so rapid and the experience with it so uniformly satisfactory, that I feel safe in saying that its introduction in such large numbers on so many roads in so short

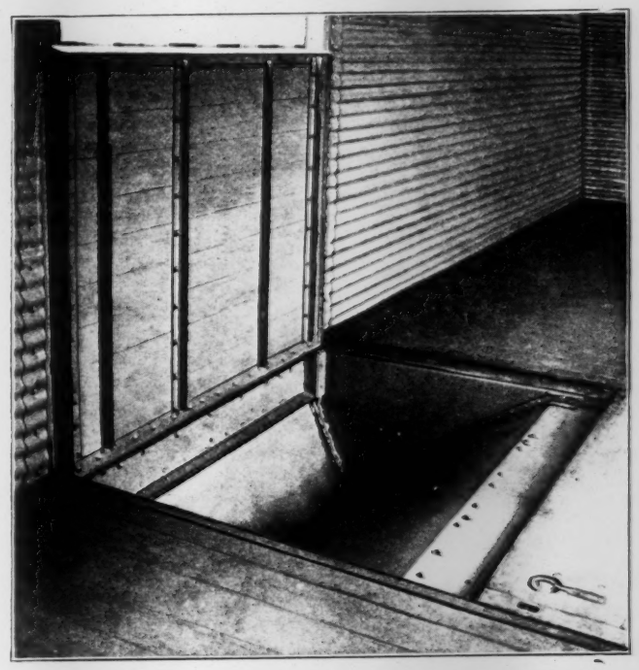

Fig. 10 Detail View of Hopper Opening in Floor of Corrugated Steel Lined Car

a time indicates more nearly a tendency toward the adoption of a standard car than has any distinct type of car outside of patented cars for special service. It is certain that there will be no backward movement to a wooden superstructure and that this car with possible modifications will remain a standard car unless some superior type of car is developed. It may be stated as the writer's opinion that no committee will ever develop a car that will be adopted as standard but that the nearest we will ever get to a standard is what may be developed by one or two persons given a free hand, and the merit of which is so pronounced that it forces itself upon the country.

With the use of structural steel there is less necessity of carrying special parts in stock on account of

repairs being largely a question of labor, and it seems that with this type of car the necessity from a repair standpoint for a standard car is decreasing. This is further borne out by the fact that for the 30,000 cars of this type we have ordered no material for repairs and carry none in stock outside of material common to all cars, except lining; of the lining, our stock amounts to practically nothing. We save out sufficient of the parts from cars destroyed to make up our stock of repair parts, but have found it necessary to use very little of this. There are, of course, many valid reasons why cars should be made to standard inside dimensions and outside clearances.

To look at the matter in another way, the wheels, axles, journal bearings, journal boxes, couplers, brakes, safety appliances, etc., which constitute the removable and perishable parts, are all standard and when it is remembered that nearly all of the remaining parts of the cars are standard rolled shapes which are easily obtained either from the mill or from stock in all principal cities, it is apparent that we now have in effect, a standard car, or at least a car of standard parts. A car of different dimensions would not increase the cost of maintenance as long as standard shapes are used; nor would it if every lot of cars is designed differently, as long as proper strength is maintained, and any change in design would usually be to increase the strength. In other words, to keep a car as close as possible to standard and reduce cost of maintenance, rolled shapes should be used in preference to pressed shapes where possible.

It is my belief that the people who are urging the adoption of a standard car for maintenance reasons have in mind the remaining wooden cars for the maintenance of which large quantities of timbers and castings have to be kept in stock. It is of vital importance that the parts be standardized if that style of construction is to be continued. It should not be overlooked that in a car constructed with rolled shapes, these parts seldom need renewal even when the car is wrecked, as they can easily be straightened or formed to the original shape at any car repair point, while wood would have to be replaced and pressed shapes would call for special dies to reform them. With a wooden box car the amount of material necessary to carry in stock and use for repairs increases rapidly with the age of the car. With a steel frame box car the amount of material necessary to carry in stock and use for repairs outside of parts common to all cars does not increase with the life of the car.

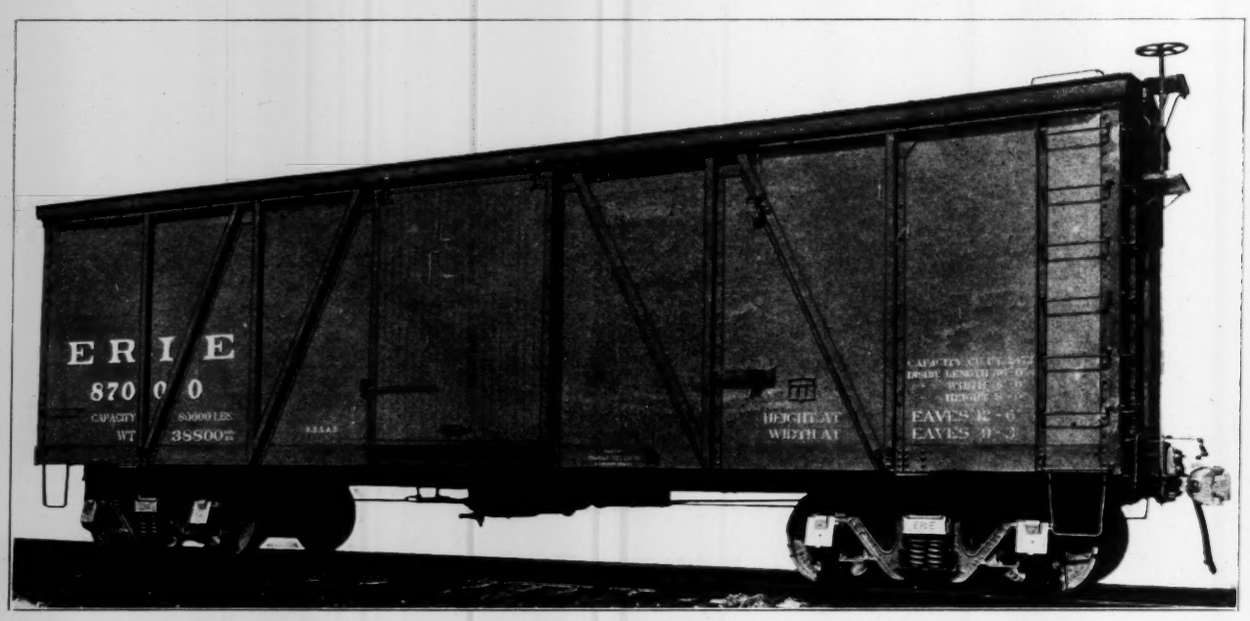

Fig. 11 View of Steel Frame Inside Sheathed Box Car in Use on the Erie Railroad (36 Ft., 40 Ton

The wind resistance on the steel frame box cars with inside sheathing is slightly greater than on a smooth outside sheathed car, but on the other hand, it is less than on any ordinary type of stock car. The effect of wind resistance between box and stock cars, has never been great enough to require any distinction between them as to the number of cars that could be hauled in a train of either and is really a refinement that not even a dynamometer car can detect. A small change in the angle or velocity of the wind, or difference of the number of wheels running to one flange, or trucks somewhat out of square, affects the haulage of the train too much to enable any satisfactory figure for the difference in the wind resistance of the various types of car to be obtained. There is a certain stretch of track on the western plains of about 40 miles without a curve and practically level where high winds are frequent, on which the haulage capacity of locomotives

is dependent principally upon the wind, and yet even there it was found practically impossible to distinguish between the wind resistance of stock and box cars. From this, it is evident that the wind resistance of steel frame inside sheathed box cars as compared with outside sheathed cars may properly be ignored.

In the summer of 1911, we lined one of these steel frame cars with corrugated steel and found it to be as simple a matter as lining with wood, Figs. 8 and 9. We lapped and rivetted the sheets, which were No. 13 gauge, between the door and end, and had the corrugations on the side and end coincide, pressing into special corrugated angles in the corners to break the joints. At the floor, we straightened out about 4 in. of the corrugation and formed of it an angle that rests on the side sill, and on this the ends of the floor boards were superimposed, easily making as tight a joint as I have ever seen on any car. After 18 months of general service this car was brought in and on examination, found to be in as good shape as when constructed. It was interesting to note that, when inspected, the paint sealing the joints, where the side sheets lapped, was in no place seal broken, indicating that there is no material weaving or deflection of the sides. The paint was in perfect condition, there still being some gloss, indicating that in the use of steel there is no disadvantage as far as the painting is concerned. Different methods of lining with steel could be followed, and I am convinced that if experience proves that there is no damage to be feared from heat, cold or sweating, that steel lining will be largely used. But, I am also convinced that the use of steel lining with any insulation will never be extensively used as it adds to the cost and weight without affording any protection to the lading, which is not secured by the wood lining. An advantage of this construction is shown in Fig. 10, in the application of hoppers under the door openings, which were made without alterations to sills or cross bearers.

As regards the end of the car, Fig. 4, we use two 4 in. Z-bar end posts of 8.2 lb. per ft., with $1\frac{3}{4}$ in. lining which gives good service, but we intend to use on future cars two 5 in. end posts of 11.6 lb. per ft. with $2\frac{3}{8}$ in. lining for a height of 4 ft. and $1\frac{3}{4}$ in. lining above that height. This, we feel, will protect any lading that needs protection. If a car gets such rough handling that wheels or rails, or similar lading would break through, it is better to have the boards broken than to distort the posts, as the lining can be replaced at any repair track with a minimum expense, while distorted posts would require sending the car to a steel car repair point. The single thickness end lining makes convenient the application of single thickness, grain-tight end doors.

Fig. 12 Steel Frame Box Car with Metal Roof in Use by the Grand Trunk System (36 ft., 40 Ton)

Out of 30,000 of these cars, 29 have been destroyed. Based on the length of time in service, this would average a loss of approximately one car per 1000 per year. Of the cars destroyed, 15 were burned, 14 were destroyed in wreck, 10 cars being destroyed on foreign lines. As the loss of cars by fire is in no way affected by the details of construction, I will eliminate them from the calculations. This then, based on the

length of time in service would give about one-half car per 1000 per year destroyed in wreck. As there is no appreciable deterioration of these cars in service, it is safe to assume that in the same service substantially the same rate of loss would continue, while with wooden cars the rate of loss would increase each year.

A conservative estimate shows that there are today approximately 65,000 steel superstructure cars, including outside sheathed, in service. Of this number 30,000 are Canadian Pacific Railway and nearly all the remainder belong to the roads whose names appear on the cars illustrated herewith. These I am able to show through the courtesy of the officers in charge of the mechanical departments of the several lines, whom I wish to thank for their willing assistance.

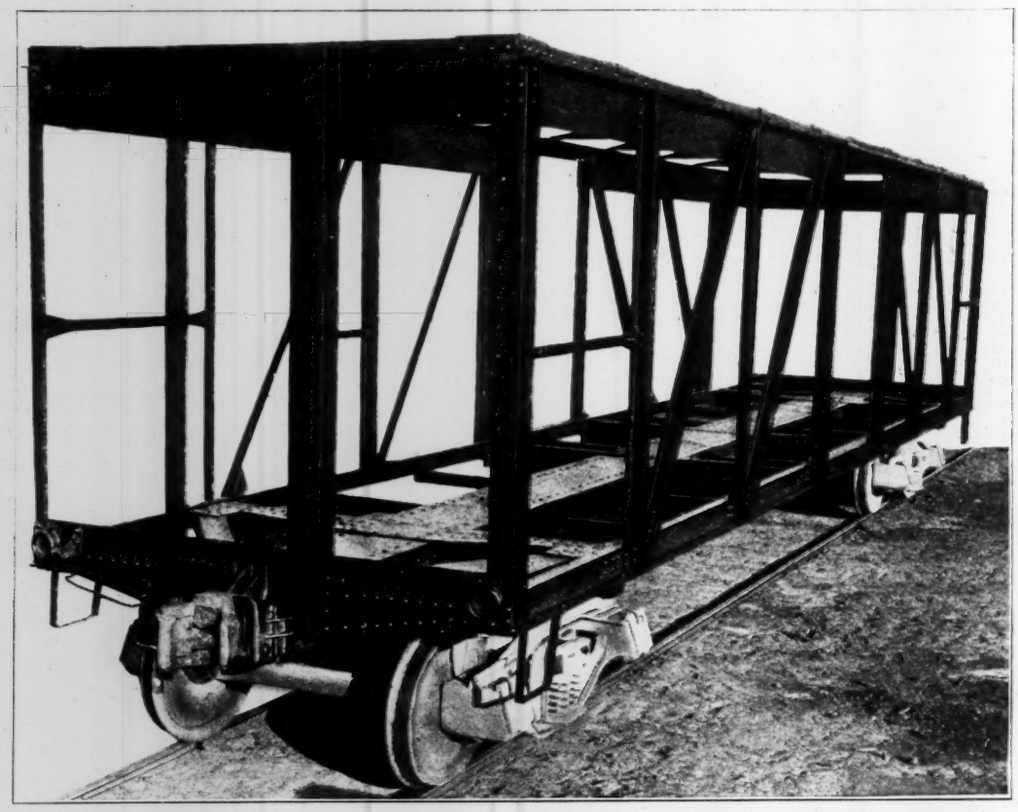

Fig. 13 View of Steel Frame of the Rock Island Car (Fig. 2) ready for Sheathing

DISCUSSION

H. H. Vaughan thought that Mr. Burnett's position was sound, that the structural steel car was to all intents and purposes a standard, as far as any car could be standard. He believed that one standard type or design of car would never be adopted. There were sure to be improvements and alterations that the different roads might think desirable; if standard material, easily obtainable, were used, and if certain parts, mentioned by both Mr. Rink and Mr. Burnett, were kept standard, that would be as close to the standard car as would ever be approached.

The draft castings, arch bars, bolsters and some of the other parts should be standardized to a greater extent than at present. It was absurd that the slight variations in these parts necessitated their being obtained from the car owners when repairs were made on foreign lines.

Mr. Vaughan thought that Mr. Rink was not quite fair to the Canadian Pacific Railway in his illustration of type H underframe (Fig. 28). The diagram showed the underframe without any cover plate, the bolster and the two 15-in. channels running through. The company did intentionally employ a cover plate running about 5 ft. long from the back of the draft casting to about 3 ft. back of the bolster underneath the sill.

Between the bolsters and the sills, the cars were practically unsupported except for side bracing. Mr. Vaughan stated he would not advocate this construction if the Canadian Pacific cars were running in heavy coal trains or under such conditions as the Norfolk & Western have in their coal service. In designing a car it was necessary to figure on the service the car was generally going to run in, not the service it might run in. It was felt that 60 per cent to 75 per cent of the service to which the box cars were put, both in Canada and the United States, was service in which the old type of underframe would stand up satisfactorily. These figures were justified by the result obtained with this type of car, in a period of five years, as given in Mr. Burnett's figures.

As far as was known, not a single car had shown vertical weakness in the center sills. The omission of that cover plate had introduced a certain amount of longitudinal weakness through the center, as well as buckling sidewise, but in no case buckling vertically. It was thought that the floor would be sufficiently stiff to prevent any lateral buckling

of the center sill, and some floors were so loose that they could not have acted that way if the car had been permitted to buckle. The center sills and the side sills had ample strength to hold up the corners of the cars under general conditions, and the saving of 500 lb. of weight there, 500 lb. in the cover plate, and a few hundred pounds here and there, was what had made so light a car. The company had a car weighing 36,500 lb., carrying 40 tons, which could be loaded to 93,000 lb., permissible loading.

Mr. Vaughan called attention to the advantage of reduced weight on net earnings, and not on the cost per ton-mile; the company's figures for 1913 showed that 22.34 tons per loaded car-mile were carried, and that the percentage of light car mileage was 28.5 per cent of the loaded car mileage, which gave an average load of 16.8 tons per car-mile total. The weight of the average car unloaded was 18 tons, so that the average weight of car loaded was 34.8 tons. That was not a bad figure for a large number of roads in this country handling general traffic. The Canadian Pacific handled a large amount of grain, and while it did not have much coal, the average load was fairly good.

Assuming this average car weighed 1 ton more, to begin with, without any question as to whether the train rating would always be changed or not, the weight of the car loaded would go up to 35.8 instead of 34.8; in other words there would be an increase of the ton mileage of 2.85 per cent; or if operating on a ratio of 70 per cent, under this changed condition of weight, the operating ratio would be 72 per cent instead of 70 per cent. The net earnings would drop from 30 per cent to 28 per cent, which was a difference of 6 per cent in net earnings.

The question of weight was an important one in car design. A lighter car might cost $5 or $10 more a year to keep up than a heavier one, but it would save two or three times that in the weight to be hauled uselessly about.

Mr. Vaughan agreed with Mr. Rink in the question of sheathing. The Canadian Pacific owned a number of cars which had shrunk considerably, but there had been few cases of damage cases due to them. It was not a difficult matter to tighten them, as Mr. Burnett said, and the only reason why this had not been done was because the company had not received a sufficient number of complaints to justify taking the cars out of service and doing the work. The vertical sheathing would be, possibly, a preferable arrangement if it could be accompanied with an economical and convenient design of side framing. But this would be difficult to accomplish for the truss form of side framing naturally lent itself to horizontal sheathing. In vertical sheathing horizontal members would have had to have been introduced to take care of the fastenings, as in the Pennsylvania Railroad cars. The distance from the top plate to the sill was too great to permit the side sheathing to be placed vertically without any support.

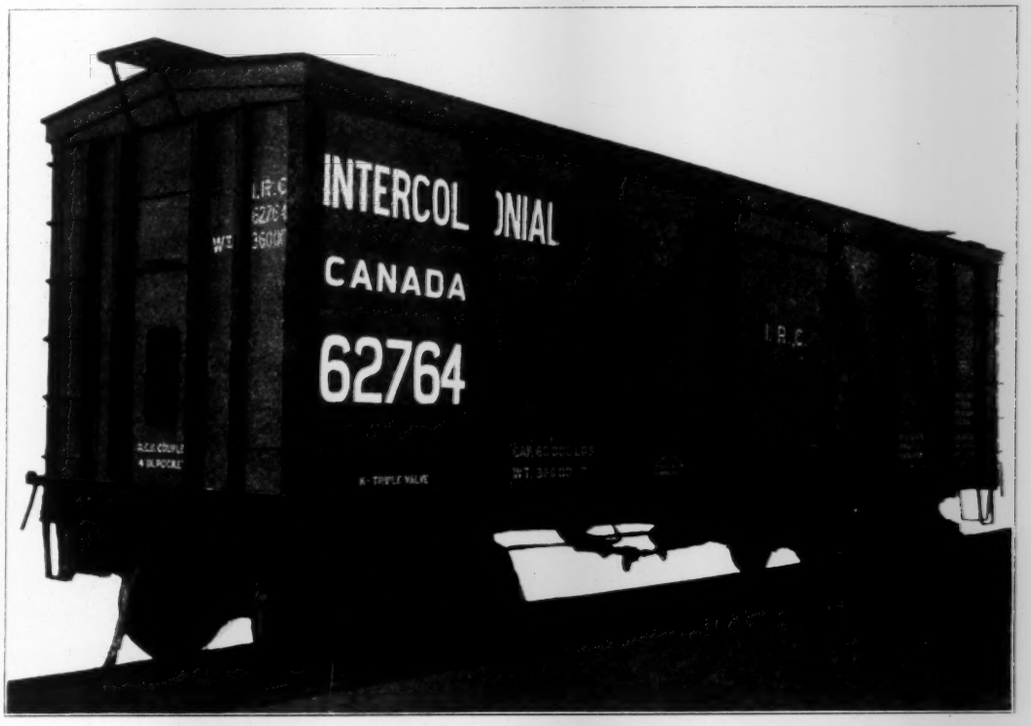

Fig. 14 Inside Sheathed Steel Frame Car used by the Intercolonial Railway (36 Ft., 30 Ton)

Mr. Rink referred to end reinforcement repairs. The Canadian Pacific Railway were using very extensively the same style end as was used on the steel frame car for repairs of all wooden box cars: it simply put in two Z-bars and reinforced the ordinary end post, and put the $1\frac{3}{4}$-in. lining inside.

He thought the roof question was the next to come up for discussion: the three types described were at present the most widely used. The Canadian Pacific had been an advocate of the inside metal roof for a long time, though they had experimented with the all metal roof, and would be interested to know what results were being obtained.

Mr. Vaughan in discussing the history and the develop-

ment of this type of car, said he felt that he was correct in saying that this type had been originated on the Canadian Pacific Railway when W. E. Fowler was General Master Car Builder. The car was the result of a conversation between Mr. Fowler and Mr. Vaughan relative to policy in turning toward steel underframes.

B. D. Lockwood stated that if Mr. Rink's recommendations advocating standardization of cars were to be followed a committee should be appointed by the Society to design such standards, indicating in their work the minimum of strength and empty weight and the reasons therefor that should be acceptable from a railroad standpoint, so that car builders could govern their action properly in competition. The joint efforts of the railroad committee of the Master Car Builders Association and the United States Railway Mail Service in connection with the standardization of postal cars resulted in a series of recommendations, and the adoption afterward, of standard specifications, in which the minimum acceptable section moduli was given as the governing factor for all principal members and there was no reason why this could not be done in the case of recommended standards for freight cars.

Mr. Rink had outlined a system of calculations, but whether his deductions were to be considered as generally expressing the ideas of railroad mechanical engineers throughout the country was a question, and the whole matter should properly be referred to a committee.

H. Wade Hibbard called particular attention to the necessity of designers keeping in close touch with service conditions. A number of years ago he was connected with a large trunk line, where it was the declared policy in the mechanical department that the designers should go frequently into the shops and into the repair yards and into the scrap yards for the purpose of studying how the equipment had failed in service. Later the policy was changed and the men were not expected to carry on that sort of close contact with the service conditions, with the result that locomotives that were found at the main shops to be bad in design for upkeep were reordered from the locomotive builders with the same old mistaken design. The policy of one of the large steel car manufacturers of the country was a good one: they had a college educated man go into the shops and learn the business completely; he afterwards was kept traveling among the railroads that purchased steel cars from his company for the sole purpose of learning the good and bad things about these cars in actual service, reporting the result of his efforts to his company.

W. F. Kiesel, Jr. (written). There is one feature in the calculations for end strength to which Mr. Rink has not especially called attention, and that is the ratio of stress to strain under end shock. The important point to consider is that at the bolster. This ratio in the 14 cars enumerated varies between 0.033 and 0.118. The high figures are due to the great distance between the center line of the drawbar and the neutral axis of the sills. The area of the center sills at the bolster varied from 19.08 to 36.18, and the average is 24.75. Without using any additional metal in the center sills the ratio of stress to strain can readily be reduced in many of these cars to the advantage of the strength of the car.

Both Messrs. Burnett and Rink seem to favor the Z-bar posts and braces because they are made of rolled material, and, as stated by them, can be readily obtained. This does not seem to be a good argument, as it is well known that standard sections of rolled material cannot always be obtained on short notice; in fact, within the past year, the steel mills have quite frequently reported that certain angles, I-beams, etc., could not be furnished in less than three or six months.

The four following questions seem important: First, is the box car with steel side frames all that it should be? It has been argued that shrinkage of lining, driving of nails in lining to secure blocking, breakage of tongues and grooves, etc., will cause leakage, necessitating constant repairs, and that the car with steel sheathing and wood lining is closer to the ideal in box car construction.

Second: in box cars without sheathing, shall all posts and braces be made of rolled steel, or all pressed steel? Advocates of pressed steel assert that pressed posts and braces are lighter per unit of strength, because they can be formed to the required shape; that they can be formed with sufficient surface at the ends for the number of rivets required to develop their full strength, whilst Z-bars and other rolled forms require gusset plates for this purpose; that they are not likely to be damaged by push-poles, and, if damaged in wrecks, can be readily straightened and restored to approximate shape; that when absolutely necessary to replace them they can readily be obtained from car owner or builder, and that it will not be necessary to wait for any special rolling of material.

Third: should not the posts and braces be considered strictly as beams supported at top and bottom, in combination with straight tension and compression, as members of the side truss? Mr. Rink indicated that flattening of pressed posts and braces, where they connect with side sills, has a weakening effect, which further indicates that he considers them as cantilevers held in vertical position by the side sills and frame braces connected thereto. In wooden cars the posts and braces were strictly beams, and not cantilevers, as they rested on top of the side sills, either directly or on castings with shallow pockets. Side sills of box cars have too little resistance against torsion to hold the posts and braces vertical; they, therefore, must depend on the strength of the side plate and the tying effect of the carline. If, in addition to this, a solidly riveted roof is used, the tops of the posts and braces are securely held in proper alignment and the stability of the side truss is assured.

Fourth: is it not imperative to use diagonal braces in the end framing? No argument need be presented here for this, as Mr. Rink has already furnished sufficient argument, and we know of nothing to show the contrary.

It should be noted that all of the 14 cars enumerated by Mr. Rink have so-called box-girder center sills, and that the majority of them have a minimum section of about 24 sq. in. With this section area a ratio of stress to strain of 0.06 can be obtained, provided proper adjustment is made for relative location of neutral axis of center sills and center line of draft gear. It would, therefore, seem that the present designs of box cars corroborate the recommendations of the Committee on Car Construction of the Master Car Builders' Association, and that those recommendations are reasonable and conservative. A thorough knowledge of cars by the motive power officials of railroad companies will, we hope, lead them ultimately to endorse the M. C. B. recommendations referred to.

E. G. CHENOWITH[1] (written). Before a standard for the box car is reached, it appears to me that three very important items entering into the problem must be decided upon in common by all railroads, viz: (*a*) capacity, (*b*) dimensions and (*c*) design. The railroad companies are far from agreeing on either one of these items, as can be seen from Messrs. Rink's and Burnett's papers. One need only stop to consider what an enormous saving there would be in maintenance if there was only one design of car to repair, and what a decrease would result in the enormous quantity of material which is now carried if our stores need carry repairs only, say for a 40 ft., 40-ton steel frame single-sheathed box car. Under this ideal condition our bad-order cars would be on the repair tracks 50 per cent less time.

The design of a car is influenced by many local conditions, and often by a great many local instructions. It is regretted that the merit of a design of a car is too often inversely proportioned to the final weight of the car. I believe that we are now about at the minimum limit relative to weight of box cars, and the tendency is to increase, and not worry so much about the extra dead weight hauled but to give more consideration to keeping the car in revenue service more days of its life.

Steel underframes are now being applied to thousands of cars in this country and perhaps in as many designs. Whether they should carry a vertical load, or only withstand the buffing, seems to be a prevailing question. Many underframes are being applied to cars retaining the original truss rods, while in many other cases the depth of the steel underframe is made to carry the vertical load, thus eliminating the truss rods, it being claimed that the cost of maintenance of rods will offset the cost of deeper center sills. It must be conceded that in a great majority of cases where any design of underframe is applied, the wooden underframe is not disturbed, so that, therefore, the weight of car is increased to an amount equal to the added steel underframe.

The main object in view in applying steel underframes is, I think, to obtain a greater resistance capacity for buffing. The car perhaps has with the aid of truss rods properly carried the vertical load, therefore, why not add to the underframe only that which will take care of the buffing strains. To my knowledge, underframes are being applied which consist of 8 in. by 8 in. H girder beams. These girder beams set up between the wooden centersills, supporting them by means of angle brackets riveted to the flanges. To these girders the $\frac{5}{8}$-in. draft plates are riveted extending from end sill to bolster. As this design was not intended to carry a vertical load, the bolster and cross ties were not connected to the girder in a manner to carry the load imposed on the side sills. Another cheap design of an underframe of this class lies in the use of two 9-in. channels with cover plate; this design sets below the wood sills, however, and therefore requires a bolster and cross tie in order properly to apply truss rods.

In the design of steel underframe consisting of two center members, it seems to be the general tendency to apply top cover plates instead of relying on the diagonal bracing to side sill to keep the center sill from distorting in very severe service.

Referring to Table 2, Mr. Rink states that it is the whim of the designer that occasions so many different lengths of box cars. In my experience in designing equipment for several different railway companies, the consideration of a proper length car was held as a serious question and good reasons were developed in the freight traffic department before the designer received instructions as to the principal dimensions around which to design a car. The popular dimension, it seems to me, for inside length of box car is 40 ft. I know of a railroad operating over 12,000 cars of this length and they seem to meet the requirements very well.

The standardization of design of box cars will have a tendency to decrease the great variation of weights. I saw two designs of cars built within a year of each other by two railway companies, one a 60,000 lb. capacity car having a light weight of 48,000 lb., while the other, an 80,000 lb. capacity car, had a light weight of 36,000 lb., and moreover, both railway companies were perfectly satisfied with their designs.

In the design of steel superstructure cars, I am of the opinion that the side sills should be only of a proper section to complete the trussed panels of superstructure, and should not be designed as a load carrying member. This will allow the superstructure more flexibility to adjust itself to irregularities of track and eliminate the tendency to derail. A car held rigid so that the planes of the sides are always parallel will not properly take a curve.

The trouble experienced from water following beading or grooves in horizontal sheathing and then passing into the car, could, I think, readily be overcome by bevelling off the top corner of each board outside of the tongue, which would eliminate the gutter effect at points of matching where the sheathing is not entirely tight. Where single sheathing is used the $1\frac{1}{2}$ in. thickness seems to meet the requirements, and it should be tongued and grooved instead of shiplapped. Some designers are using $1\frac{3}{4}$ in. or even thicker for end sheathing, but the $1\frac{1}{2}$ in. thickness on both sides and ends with extra reinforcement at ends furnished by proper design and location of end posts seem preferable.

The proper method of designing the end of a box car or reinforcing it for shifting loads is a question all designers have given extra time and thought. The end posts of a car are of no consequence except in so far as the end plates, of whatever construction, can properly support the upper end of the posts. This evidently has been overlooked in some cases, as cars will be found having heavy steel end posts attached at top to a light wooden end plate. The end of the car should be so constructed as to resist going in as well as bulging out.

As the author stated, of all the things which should be made standard, a box car side door is one of the most important, and should be the easiest standard to obtain and maintain. Yet, few railroads have cars of different series which have doors interchangeable. I believe in the use of a roller at the top of the door and I am now experimenting with rollers at the top, and with one of the door guides at the bottom equipped with a roller. This will assist in holding the door in place, and I believe will make the door operate much more easily; it will also stop the use of a steel bar for prying the door open or closed. No mention is made in the papers of either a flush or an inside door; both types are being advocated.

There are many designs of steel carlines, and while some answer the purpose for which they were designed, others are unsatisfactory. The tendency is to figure a carline for

[1] Mechanical Engineer, Rock Island Lines, Chicago, Ill.

strength at the center, forgetting the section near the side plate. One function of the carline is to keep the side plate from spreading out as well as coming in, and therefore, should not be designed to support the roof alone. I had the occasion not long ago to inspect a steel carline which had ample depth at the center, but at the ends a part of it was bent at right angles and riveted to the inside of the side plate angle, so as not to furnish any resistance to the side plate going out. I am of the opinion, that if need be, we should sacrifice head room to get carlines nearly straight on the bottom edge, which will act as a tie rod in tension and be in best of shape to withstand compression.

The draft gear and its application to the car are the most important details of any car; yet while this fact is appreciated by all railroad men, a great diversity of opinion exists among them as to what is best. Many are holding to a spring gear, while others claim that the friction gear is a "life saver." Does the good obtained from the use of friction gear warrant the extra expense? There should be a minimum allowable area for draft sills, which should be effective and well balanced about the center line of draft. I have often wished that the standard drawbar height was increased at least 1 in., which would allow a better application of the high capacity draft gears.

The steel frame box car with single sheathing has, I believe, come to stay, with some modification, perhaps, in the general design, to overcome weaknesses which may develop in years of severe service.

C. A. Seley[1] (written). I acknowledge with many thanks the compliment paid me in the second paragraph of Mr. Burnett's paper; my connection with the development of composite freight car construction was very interesting and a deeply appreciated opportunity in working out that step in the evolution of car construction. About 15 years ago three factors influenced some progressive railroads to the larger introduction of steel in framework of freight cars: increased capacities, greater structural strength to withstand operating stresses, and the approaching equalization of costs of steel and car lumber, particularly for framing.

For new cars, I believe there is now no good argument against steel for the complete framing, so combined that the sides will assist in carrying the load. The question then arises as to how far to go with the use of steel for such parts of the car as merely contain or shelter the load. Manifestly, floors must continue to be made of wood to enable blocking of the lading. Aside from this there are many predictions of all-steel box cars. In my opinion this will be the ultimate construction, but doubtless slow in general adoption on account of the still favorable balance in favor of the cost of wood for lining and sheathing, and in combination with steel plate for roofing, whether of the so-called outside or inside type. When the all-steel box car does come, it will have to be arranged with ventilation features to prevent damage to lading from sweating and from accumulation of excessive heat which may unfavorably affect many high-grade commodities if shut up in a steel box without such ventilation.

The Canadian Pacific Ry. is to be congratulated as being the pioneer in developing the inside sheathed box car, and judging from the record as stated by Mr. Burnett, and giving due weight to the statement that "practically no reports of loss or damage to lading due to shrinking" being received, that construction would seem to be fully justified when proper lumber and care in building are used.

Both authors have discussed the advisability of the standard car. I doubt very much if this idea will ever be consummated, even to the extent of the standard material idea advanced by Mr. Burnett. The difficulty in the way is the human element; if we all thought alike it would be possible. The Master Car Builders Association has standardized the parts essential to interchange, and under this head may be listed couplers, air hose, wheels, axles, journal boxes and contained parts, brake shoes and brake gear parts. The Government has standardized safety appliances. This to the uninitiated would seem to settle most of the difficulties in car repairs, but we all know that very few of the Master Car Builders' standards are really standard in exact detail, and the Interstate Commerce Commission safety appliances necessarily give considerable range of dimensions and application within which their requirements may be fulfilled.

It is difficult for one not in railroad service to appreciate the whole problem, and particularly the influence of interchange requirements. A railroad may be of low gradient, equipped with light power, and have a class of traffic that would ordinarily keep their cars on their own line, and the cars which would most economically fulfil all requirements for such a line and service can be readily imagined. In interchange, however, these cars might be required to go anywhere from coast to coast, in all kinds of tonnage trains, through hump yard trials and other tribulations never experienced on the parent road.

Furthermore, a railroad car designer can never afford to worship standards in view of the rapid evolution in transportation. This may be illustrated by the progress of the Master Car Builders Association in adopting standards for car axles. The 3¾ in. by 7 in. axle for 40,000 lb. capacity car was standardized in 1873; the 4¼ in. by 8 in. axle for 60,000 lb. capacity car followed in 1889, a lapse of 16 years; then in only seven years, the 5 in. by 9 in. axle for 80,000 lb. capacity car was standardized in 1896; and that was followed in 1899 by the 5½ in. by 10 in. axle for 100,000 lb. capacity cars, and the end is not yet. The only limit is the gage and endurance of rails for wheel loads, and all above the rail must be proportioned to the stresses.

O. C. Cromwell[1] (written). Referring to Mr. Burnett's design of steel upper frame box car I observe that no diagonal braces are used in the end framing of the car, such as are generally used in the end of a wooden frame car. These braces tend to keep the end framing of the car square, and while their omission would probably not be apparent for the early life of the car, would it not be expected, as the car ages, to find a loosening up of the riveted joints uniting the posts with the plates and underframe? While the car is new, the end sheathing will serve to keep the framing straight, but will not these end boards loosen up in time through shrinkage?

The paper states that the lumber in these cars is very carefully selected, only specially dried lumber being used. When the car is new, this, of course, tends to keep the framing square, but as this class of car becomes more numerous, there will be a letting up in this feature of obtaining specially

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[1] Mechanical Engineer, Baltimore & Ohio R. R. Co., Baltimore, Md.

dried lumber, and the shrinkage of the boards will be more pronounced, and their effect as a brace will become less efficient. Also we know that on gondola cars the side planks decay under the side stakes and under the corner bands. Would not a similar action of the lumber be expected in this character of car as time went on? Would not this, in turn, lead up to the loosening of the framing? Also will there not be a tendency for water to get into the planks through the bolt holes and start decay?

The irregular distribution of the loading in cars throws twists into the superstructure, and this has a tendency to rack loose the riveted joints. Also, the jacking up of cars to remove the wheels from the trucks throws similar strains into the framing.

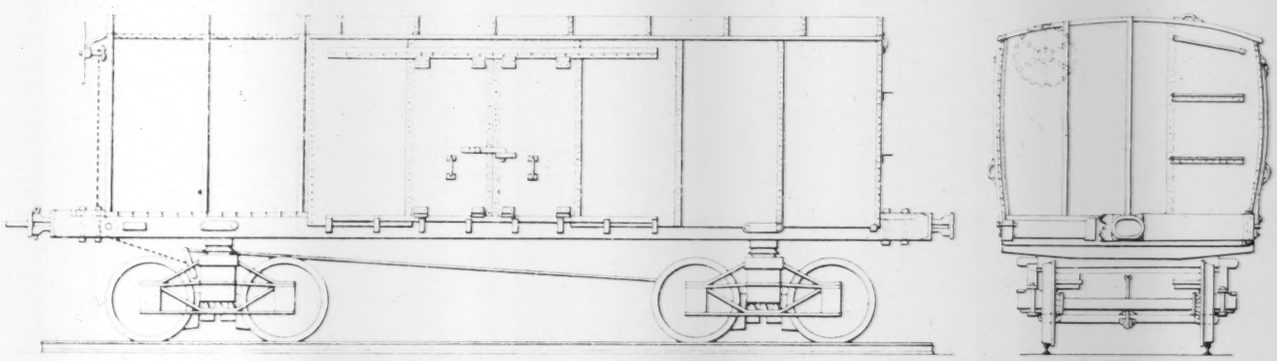
Provision has been made in this car for taking up the shrinkage in the sheathing by providing slotted bolt holes in the framing for securing the bolts holding the sheathing in place. By slacking up these bolts and straining down the tie rods, the boards are to be drawn to tight joints. Recently I had an opportunity to look over the outside frame box cars of another line, and found that they were not using the slotted bolt holes above referred to, and upon inquiry, was informed that these boards could not always be drawn tight by the use of tie rods, and that since they would not shift into place by the use of the tie rods, their use could well be dispensed with.

I would like to inquire if there is any provision made to forestall the tendency of sheathing to decay back of the posts and braces. At one time, the Baltimore and Ohio operated some outside wooden frame box cars with inside sheathing running longitudinally, and considerable trouble was experienced with the sheathing deteriorating or rotting back of the posts and braces. There was also considerable trouble in maintaining the superstructure of these cars in a square condition, and a different form of roof bracing construction had to be resorted to. I would be interested to learn if the outside steel frame cars are a little later on going to develop the same peculiarity as to rotting of the sheathing that developed in the old wooden cars.

I understand that the joints in the boards are tongued and grooved, and I have been informed that on some of them the tongues and grooves are made a little deeper than is usual in order to insure against opening to the weather in the event of the boards shrinking. In case the boards shrink, being in a horizontal direction, has there been any trouble, during driving rains, with the water being driven around the ends of the boards and working into the inside of the car? I would like to inquire if anyone has had any experience with other forms of board joints than the tongue and groove?

Recently we have seen the introduction of steel ends to wooden frame box cars, and it occurred to me in connection with the end framing for steel outside frame box cars, that notwithstanding the fact that the $1\frac{3}{4}$ in. thick boards were used in the ends, these boards will be broken out by the shifting of the loads, and the application of the steel plates to the ends of the cars would protect the boards, and act as a stiffener to the end of the car. Possibly this phase of the question may have been given some consideration and it is mentioned at this time in order to bring out this feature.

Has there been observed any tendency for the sheathing boards to swell, due to the changes in weather conditions? I believe that it has been the general experience that when kiln-dried sheathing is applied to box cars, and driven up too tightly, trouble will result in damp weather with the boards swelling, and the sides of the car buckling. This is experienced with narrow widths of sheathing applied vertically. With sheathing of wider widths of boards laid horizontally, in which the moisture is retained longer, would it not be expected that there would be more swelling of the lumber, and for this reason, it may be that the slotted holes in the posts for securing the sheathing are useful more for the purpose of taking care of the swelling and shrinking of the lumber than for taking up any wear.



Design of Iron Box Car built by the Baltimore & Ohio R. R. in 1862

I believe that there are some outside frame cars in which the siding is applied vertically; I trust that there will be some points brought out in regard to this paper that will give some light on the advantages and disadvantages of the two methods of applying the sheathing.

Referring to the corrugated steel lining used instead of lumber for sheathing, the Baltimore and Ohio Railroad in 1862 built some iron box cars, which had wooden underframes, but the body and roof of iron plates. The illustration shows one of these cars that had a body 24 ft. $\frac{1}{4}$ in. long, 8 ft. 2 in. wide, and about 6 ft. 6 in. high. The side and end plates were $\frac{3}{16}$ in. sheets, applied vertically, the sheets being about 37 in. wide, and the roof sheets about 32 in. wide, all sheets being riveted together at the joints. The sides were slightly convex to give them stiffness, as was also the roof, but the end plates were applied perfectly straight. The sides, ends and roof were stiffened with 2 in. by 2 in. ribs of ash. These cars proved unsatisfactory, because in summer they became so excessively heated that they spoiled the merchandise, and in sudden changes of weather, produced sweating, with damage to lading, and the cars had to be finally withdrawn from

service, and used for special trade, and were ultimately converted into workmen's storage sheds, tool houses, etc. I would be interested to know if any of the corrugated iron cars have shown up any of these defects.

Referring to Mr. Rink's paper, the several tables bring out the principal dimensions in comparison very clearly, and in looking them over, one is impressed that in the main, the dimensions are very close, and that it would need only the guiding influence of some association to eliminate these variations to bring them within very much narrower limits. The metal parts, rolled shapes, etc., used in the construction of these cars, could be found in the stock of any railroad, in case the cars were damaged or needed repairs.

The side posts and end posts, side braces and end braces, corner posts and door posts, should be brought down to a standard; they are now very nearly this, as shown in the tables. The side posts, Table 4, are of the same dimensions for all the cars, except in the case of the 4-in. pressed steel shape, while there is only a slight variation in the side braces, and they should be easily reconciled. Several different cars have the same corner posts, and as they are very much exposed members, it is important that they be alike on all cars. Table 6 shows that the end posts are very close, and have very little variation.

The point brought out in Mr. Rink's paper, with reference to the height of the floor above the rail is certainly an important one, and it appears to me that there is no good reason why we should have a variation of $6\frac{3}{4}$ in. in this height, as brought out in Table 7; this, too, affects largely the height of the truck. As it is desired to work towards standard and interchangeable truck parts, the height of the truck is an important one to bear in mind.

W. S. Atwood (written). The first steel frame box cars built by the Canadian Car & Foundry Company were considerably heavier than those now being built. The car referred to in Fig. 1 of Mr. Burnett's paper weighed 41,200 lb.; this, of course, was partly due to the fact that the car was constructed from stock material, no special material having been ordered. In fact, the side braces and posts were made of heavy angles in place of the light Z-bars, as at present in use and as originally intended. There are several details which have been changed from time to time in order further to increase the efficiency of the car. These details have also had a tendency to lighten the weight, so that now a car weighs less than 37,000 lb.

Referring to the grading of the lumber, with the first cars of this type, there was some difficulty experienced in securing the proper grade of lumber and also in properly drying it for application to this type of car, as owing to the thickness, the lumber had to remain in the dry kilns longer than was necessary in the case of the thinner sheathing used on the outside sheathed car, and on this account the car companies were not, in all cases, equipped with sufficient dry kiln capacity. The lumber dealers, however, have met the car builders in attempting to prepare a satisfactory grade of lumber for these cars and no difficulty whatever is encountered at the present time in getting an adequate supply of a satisfactory grade.

As to the allowance for finishing, in the first lot of cars built by the Canadian Car & Foundry Company, owing to the condition of the lumber it was necessary to use, it was thought advisable to purchase 6 in. stuff to finish 5 in. face, but owing to the amount of this grade of lumber which has been used in the last two or three years, it is now possible to get a satisfactory grade, purchasing 6 in. stuff to finish $5\frac{1}{4}$ in. face, which makes possible quite a saving on a large order of cars.

Judging from the service which this type of car has given to date, and also from the favorable criticism it has received from practical railway men, it would seem that it would eventually replace the outside sheathed car, and owing to the simplicity of the design it would seem possible for the railways to adopt a standard car of this type in so far as the general dimensions and sections are concerned. The adoption of a car with standard inside dimensions and outside clearances would be a matter of considerable importance to the car builders, as material could be stocked and available for building cars required for quick delivery for any of the railways which had adopted this type of car. It would also allow them to place large orders for the inside sheathing which could be prepared and stored a sufficient length of time to make it entirely suitable for this type of car and eliminate any possibility of trouble from shrinkage.

From Mr. Burnett's experience with one of these cars lined with corrugated steel, and also from the experience which others have had with steel lined box cars, it would seem only a question of time until the wood inside sheathing would be replaced with steel. I also believe that, in addition to the lining eventually being made of steel on these cars, some type of all steel roof will also be adopted, thus eliminating wood entirely, with the possible exception of the flooring.

I do not agree entirely with Mr. Rink in his statement that engineers did not understand the importance of low fiber stresses in the early designs of steel underframes. There is no question about this not receiving the same attention in the early designs as it is receiving at the present time, but I think that the desirability of showing as favorable a cost and weight of the all steel and steel underframe cars as against the all wood cars had a great deal of influence on the early designers. Since these early designs have gone into service a great deal of information has been accumulated in regard to these stresses and the importance of strong construction is now receiving more consideration, so that there is not the same comparison made between the steel car and the wooden car as was made by the early advocates of steel car construction.

The statement of Mr. Rink, that vertical sheathing is preferable to horizontal on account of its protecting the lading against water, is hardly borne out by the results which have been obtained with cars with the horizontal sheathing. With cars constructed with a suitable grade of lumber and with reasonable care at the joints, there should be no possibility of the lading becoming damaged with water. In fact, upon inquiry from officials who have several thousand of these cars in service not one complaint was known to have been received where the water had damaged the lading. I think the horizontal sheathing has many advantages over the vertical.

The advantages that Mr. Rink shows would result from all the roads having cars built of this type using uniform sizes of material cannot be emphasized too much. If any large number of railways using this type of car could agree on a uniform inside dimension and a uniform size of sheathing, it would certainly facilitate the procuring of material

and would result in eventual benefit to the railways. It would enable the car builders to arrange with the lumber manufacturers for large supplies of this particular lumber, which could be thoroughly dried and satisfactory for use, thus eliminating any need of rushing the material through the kilns in cases of short delivery.

On the first cars of this type, the diagonal braces in the end panels, which Mr. Rink refers to, were applied but owing to the stiffness given to the frame from the heavy inside sheathing used, both the side brace and the end braces were omitted after the first few cars were built. There has been no trouble experienced from insufficient support for the corners of the car and by using the end braces as verticals the advantages against protection from shifting loads would warrant, I think, their being used in this way instead of as braces. The corner of this type of car at the eaves gets a great deal of support from both the side and end lining and judging from the service which cars have given under my observation, it would seem that this support was ample.

I would heartily favor Mr. Rink's recommendation as to the use of door hangers with rollers and to convince one of the desirability of this feature one would only have to put in a little time at the freight sheds and see the difficulty which is experienced in opening a large number of side doors.

As regards the standard height from the rail to the top of the floor, I think there is no dimension in the construction of the car which it is more important to have uniform than this, in order to facilitate as much as possible the unloading of box cars at platforms and also to facilitate their being used as runways when placed between tracks from which freight is to be transferred.

F. M. WHYTE (written). Both papers touch upon the subject of car roofs directly and, in addition, refer incidentally to conditions which affect roof design and maintenance. The steel underframe is getting to be pretty well understood and is quite universally used, and information about the steel upper frame is accumulating rapidly so that it is fair to presume that the remaining part of the box car, the roof, will be given more careful consideration in the near future.

In Mr. Rink's paper, mention is made of possible loose rods, posts and braces, having a serious effect upon the roofs by permitting too much weaving of the upper structure, while in Mr. Burnett's paper it is explained that some twisting of the car body is desirable to permit the car to adjust itself to uneven track; apparently some weaving of the body is desirable and yet it is possible to have too much, which is believed to be the general opinion of those who have given consideration to the subject. However, independent of this concededly necessary weaving of the body of the car as a whole, the end framing needs, from the standpoint of the general framing and from that of the roof, more consideration than has been given to it. The end plate is a very important member of the body framing; it ties together the ends of the side plates; it receives a large proportion of the shocks given to the end posts by the shifting of the loading; and it receives the momentum of running boards, brackets and ridge pole when the car is suddenly started or stopped. Further than this, in many of the designs of end framing shown in Mr. Rink's paper, the outer ends of the end plate act as cantilevers in assisting to transfer the load on the ends of the side sills to the center sills through the end posts. The important exceptions to this condition are those designs shown in Figs. 19, 20, 24 and 25, in which the diagonal bracing extends from the bottom of the center posts to the top of the corner posts. Fig. 25, showing the end framing recommended by the Master Car Builders Association committee.

The end plate is also an important part of the roof proper because in all types of roofs some member of the roof is attached to the end plates. As more attention is given to the roofs in the future it is probable that something will be done to the side and end-framing which will assist the roof. There are a few railroad men who think that the roof, meaning that part which sheds water and carries the roof loads, can be safely used to assist in keeping the rectangular box of the car body in proper shape, but a great majority think that this is quite impossible, at least within reasonable weights for the roof. It seems much better, from an operating standpoint and from the standpoint of weights, to permit the body to weave more or less and to provide a flexible roof to cover it.

There is no very good reason for the confusion which appears to exist concerning what constitutes the roof; aside from the carlines, the roof proper is the material used to support the roof loads and to shed water. With the inside roof, the outside roof, and the roof with two courses of boards and a course of felt between them, the roof boards are quite as essential as are the steel plates in the first two, and the felt in the last one, and when the roof boards are damaged the *roof* is damaged. Mr. Rink says that the inside roofing sheets should last for a good many years if the roof boards are replaced every four years; this means that the life of the roof as a whole is four years. The roof boards cost about as much as the roofing sheets and too frequently this fact is overlooked.

Concerning the weights of roofs, the double board roof with felt between weighs the most; as between the inside and outside roofs with the same thickness of steel, the inside will generally weigh somewhat more than the outside roof on account of the additional framing necessary to support the roof boards above the metal sheets of the inside roof. However, the weight per square foot throughout the car, is practically the same for both; the all steel made of No. 16, U. S. gage will weigh least. An all steel roof of plates 1/8 in. thick, referred to by Mr. Rink, would weigh more than either the inside or outside roofs with No. 22 U. S. gage steel roofing sheets, but the thickest sheets of which the writer knows is 3/32 in., which would weigh somewhat less per sq. ft. than the inside or outside roofs even though the latter have roofing sheets of No. 26 U. S. gage. The No. 24 U. S. gage sheets are generally used for either the inside or the outside roof and as it is the mean of the two extremes of No. 22 and No. 26, referred to by Mr. Rink, it will be used in the following comparative weights.

Considering roughly that the area of the roof is 400 sq. ft. and neglecting additional thicknesses in joints, covering strips, etc., the weights per roof would be about as follows: double board roof, 2640 lb.; inside or outside roof No. 24, U. S. gage sheet, 1728 lb.; all steel No. 16 U. S. gage, 1020 lb.; all steel 3-32 in. thick, 1530 lb.; and all steel 1/8 in. thick 2040 lb. Thus the all steel roof of No. 16 U. S. gage steel will weigh about 700 lb. less than the inside or outside roofs with No. 24 U. S. gage roofing sheets.

There is also considerable misunderstanding about the first cost of various types of roofs, whereas under present conditions, there is not much difference in the costs of the various types. With the double board roof the extra course of boards and the felt will cost about the same as the metal sheets of the inside and outside types. The all steel types with No. 16 U. S. gage galvanized steel or 3-32 in. black steel will cost little, if any, more than the other types. However, considering the ultimate cost to the railroad company, it is necessary to go somewhat deeper than the first cost of the roof; for instance, Mr. Vaughan has said in the discussion of these papers, that it costs $12 per ton per year for hauling, but some prominent railroads put this cost as high as $22 per ton per year; however, if the mean of these, namely $17, is accepted it will be understood how important it is to reduce to a minimum, the material used to turn water and to carry the weight of a man or two. The cost per year for hauling 1000 lb., whether the rate per ton per year be $12 or $17, will more than pay the interest on the total cost of any of the present types of roofs including the carlines; this fact ought to impress those who are interested in ultimate costs.

Another item in connection with the roof which affects to a considerable extent the total cost of the car is the total thickness of the roof including the roofing material and the carlines and the manner in which the carlines are attached to the side plates. There is no good reason why the distance from the top of the floor to the top of the side plates should not be the inside clearance height of the car; nevertheless, in many instances the under face of the carlines is placed 3 in. to 4 in. below the top of the side plates and in such designs, the side and end framing and sheathing are the same 3 in. to 4 in. longer than necessary and entirely needless weight is added thereby, frequently to the amount of 300 lb. to 400 lb.

George W. Rink. The discussion has brought out some interesting facts, and in some cases a difference of opinion still exists as to the advisability of a standard box car. While it is true, as mentioned by Mr. Seley, that the capacity of freight cars has materially changed since 1873, we have reached a stage of development wherein it would be of immense benefit to all concerned if one standard type of car were to be purchasd by all railroads, this design to remain standard until changes are required to permit of reinforcing some detail, found by experience necessary to modify. A number of railroads are now having cars built from practically the same designs developed by them as far back as four or five years ago, these cars giving excellent results in service. It is true that changes must be made from time to time, but they can be made along standard lines by a representative committee of railroad men assigned for this purpose. Suppose it was decided, after building a standard car for several years, that a radical change in design was necessary, some benefit would certainly be derived in having all cars purchased in that period built along the same standard lines.

The omission of the short cover plate behind the bolster in the illustration of type *H* underframe in Fig. 28 of the advance pamphlets, to which Mr. Vaughan called attention, was unintentional, and has been corrected in this publication of the paper. I am much in favor of the steel upperframe box car; and from the information contained in the discussion, it appears that the horizontal sheathing is giving excellent results, and no doubt is preferable for use with the style of side frames built on the lines of the Canadian Pacific, Rock Island and other railroads.

My object in tabulating the sizes of various members of the box car, particularly the steel upperframe car, was to call attention to the small variations in weight and size of material which exist at the present day; and as mentioned by Mr. Kiesel, this material is difficult to obtain on short notice, and more attention should be given such details, with a view of using only standard materials which it will pay the manufacturers to keep on hand.

H. H. Vaughan in closing for Mr. Burnett said that he felt the author was correct in that it was not a question of how long it took to get structural material, but that it was a quesion of not having to get material at all. It was very rare that structural material was required for repairs on the steel superstructure car. If the car was side swiped, which was one of the worst forms of damage, it was only a question of cutting the members apart, straightening them out and riveting them together again. The amount of material required in repairs of steel cars of any type was exceedingly small compared with the material required for repairing wooden cars, whether hoppers, box cars, or any other type. The only parts taken out were those that had been crowded together, or torn apart, and it was rare to find pieces torn apart under wrecks. As a rule they were in such shape that they could be cut apart and replaced.

As to the introduction of a standard car, Mr. Chenowith advocated a standard car, and then proceeded to describe a new type of car which he thought was an improvement over those in use. In the cars which Mr. Burnett called standard there was one change after another; little improvements were suggested as each lot of cars was built. The Canadian Pacific began building cars a couple of months ago, and improved them in the making by changing all the rivet spacings. It was found that the rivet spaces were inconvenient in many cases and they could be built much more easily by changing the rivet spaces. If a standard car were decided on tomorrow, the next order for cars would contain some improvements and changes. It seemed to Mr. Vaughan that the best plan was to follow standard parts and to use material easily obtainable. With steel construction, that question would largely take care of itself.

In answer to Mr. Cromwell, Mr. Vaughan said that a number of different joints were tested before the tongued and grooved joint was decided upon. This style of joint, also a joint with a steel piece inserted between the rabbet and lining running into a steel strip were experimented with. The tongued and grooved joint was found to be the best, however, in the experience of the Canadian Pacific Railway.

In reply to an inquiry as to whether or not the features of car were patented, Mr. Vaughan said that that was rather a difficult question: there were some patents on this type of car, but so far as he knew no one had ever paid any royalty on them, and he did not know of any important patents that covered the construction of this type of car.

R. W. Burnett. In closing I will make only a few remarks on some items not replied to by Mr. Vaughan or which were not fully covered in the paper.

Mr. Kiesel questions if it is advisable to use single sheathing on account of damage due to driving nails for securing blocking, etc. It is my observation that there is

nothing to fear from this source, as even our oldest cars of this type show no signs of causing trouble. This is also true concerning the absence of diagonal braces in end framing. These cars even when severely stressed, in accident, retain their squareness in end frame to a surprising degree.

If I understand Mr. Chenowith correctly, he considers that relieving the side frame of load stresses will render the car more flexible. I do not believe this would make any appreciable difference in the flexibility of the car. In his remarks concerning strength of end plates, I presume he has reference to that type of car using vertical sheathing, as horizontal sheathing assists the end plate very considerably in resisting the reaction of the end posts.

Mr. Cromwell's remarks on braces and end framing are answered in my reply to Mr. Chenowith, except that I may say it is needless to worry about twisting strains due to jacking car, as the twisting stresses received in a few miles' journey over track that has heaved, produces more racking than all the jacking the car would receive in a lifetime.

MEETINGS

SAN FRANCISCO, NOVEMBER 17

At a meeting of the San Francisco Section on November 17, the following committee was elected for the coming year: Robert T. Sibley, chairman, C. R. Weymouth, vice-chairman, C. T. Hutchinson, secretary, E. C. Jones and Thos. Morrin.

NEW YORK, JANUARY 9

The January meeting of the Society in New York was a joint meeting with the American Institute of Electrical Engineers and the American Electro-chemical Society, at which was held a symposium on the subject of Electrolytic Deposition of Metals. A paper was contributed by Lawrence Addicks, of the American Electro-chemical Society, on Limitations of the Problem of Electrolytic Deposition; another was presented by F. D. Newbury of the American Institute of Electrical Engineers on Sources of Direct Current for Electro-Chemical Processes; while H. E. Longwell, Mem.Am.Soc.M.E., read a paper on The Power Problem in the Electrolytic Deposition of Metals.

Mr. Addicks outlined, in the opening paper, the requirements of the problem involved in electro-deposition work and showed the extent to which practice has developed in this line in large refining plants. The difficulties encountered are now, more than ever before, mechanical in nature; Mr. Addicks divided these into nine classes and discussed each in detail.

Mr. Newbury, in the second paper, pointed out the difficulties involved in producing the low-voltage current used in electrolytic work in the quantities demanded in large plants. The various types of generating machinery for this purpose were discussed in detail and the limitations of each shown. Whereas the direct-current turbo-generator is available in relatively small units only and the unipolar generator unsatisfactory, on account of commutation trouble, Mr. Newbury points to the alternating current turbo-generator and convertor unit as the most practicable, on account of being economical, reliable and flexible, and at the same time adaptable to large units. He referred to the advantages of the combined alternating and direct current equipment also for use in waterpower plants.

Mr. Longwell, in the third paper, treated of the economics of the power production problem and discussed the advisability of refinements in equipment to secure greater economy, where the capital investment in the refinements might overweight the results obtained. He showed the advantages of steam power over the gas power plant of any type, a feature of which is the continuous requirement for steam to heat the electrolyte in the deposition tanks; this taken together with the presence of waste-heat boilers that are used in the reverberatory furnaces in some refining plants form a strong argument for the use of steam power. Mr. Longwell favored the steam turbine generating unit for most cases, and showed where the use of a complete expansion turbine is more desirable than a reciprocating engine and low-pressure turbine in combination, except in possibly favorable cases where reciprocating engine units are now in use. The turbine with gear-driven direct-current generator was discussed as a type of unit offering marked advantages for use in this particular field; this type was shown to have been used long enough under varying conditions to have thoroughly proven its reliability and efficiency. The paper also touched briefly on plant installation and operating costs.

PHILADELPHIA MEETING, JANUARY 17

A joint meeting of the Society with the Engineers Club of Philadelphia was held in that city on January 17. A dinner at the club preceded the meeting, at which the local committee entertained the speaker of the evening, G. R. Henderson.

Mr. Henderson read a paper on Recent Locomotive Development, illustrated with lantern slides, in which he showed that the changes of the last few years, consisting in the development of details, have been largely brought about by the necessity of taking care of greater tractive efforts as well as providing for the increased fuel consumption necessitated by the enlarged power of the locomotive. The steam reverse gear, the automatic stoker, the coal pusher, the power grate shaker, the pneumatic fire door, and numerous other developments had come into being in response to this demand. The use of oil has also enabled a larger quantity of steam to be generated with small physical effort on the part of the fireman, and the steam superheater has increased the volume of steam and incidentally the capacity of the boiler, so that now it is almost universally used on engines of high power.

NECROLOGY

HERMAN CHARLES MEINHOLTZ

Herman Charles Meinholtz was born February 7, 1868, in St. Louis, Mo., and died in the same city on December 24, 1913. Mr. Meinholtz was educated in the public schools of his native city and in 1883 entered the Manual Training School of Washington University, graduating in 1886. After a short service in the University's testing laboratory and later as timekeeper in the Shickle, Harrison and Howard Iron Works, he became an assistant draftsman for the Heine Safety Boiler Company of St. Louis. The com-

pany was then having its boilers built by contract and young Meinholtz was sent to inspect and accept the work. His keen observation, straightforwardness and courage were manifest in this service and brought him rapid advancement.

In 1892 he was made chief draftsman and in 1895 superintendent; in 1899 he was placed in charge of the company's first shop in St. Louis which he gradually improved and enlarged. In the meantime the Phoenixville shop was being developed and he utilized this opportunity for comparison when made vice-president in 1907, and worked out a design for a special Heine boiler shop which was built in 1909 at St. Louis and stands as a monument to his ability in practical design.

Mr. Meinholtz was a member of the Engineers Club of St. Louis. Since 1911 he had been a member of the Society's committee to Formulate Standard Specifications for the Construction of Steam Boilers and other Pressure Vessels, where his practical good sense and exact knowledge found full scope. His twenty-six years as designer and constructor securely fixes his work in the profession. E. D. M.

GEORGE T. INGERSOLL

George T. Ingersoll was born at Schenectady, N. Y., November 6, 1847. After receiving a public school education, he entered the Schenectady Locomotive Works as an apprentice machinist, where he remained four years. He then secured a position in the Illinois Central Railroad shops at Chicago, and after three years returned East to assist in the reconstruction of the shops of the New York Central Railroad at Syracuse. When this work was completed his company transferred him to West Albany. In 1876 Mr. Ingersoll was appointed under-sheriff of Schenectady County, a position which he filled for three years. Until 1883 he was engaged in delivering engines at the Schenectady Locomotive Works when he was made foreman of the company. In 1899 he was appointed superintendent of the Schenectady Water Works, a position he held for ten years. Mr. Ingersoll then retired from active life, and died at Worcester, N. Y., November 10, 1913.

EVERETT FLEET MORSE

Everett Fleet Morse, inventor of the Morse chain for bicycles and transmission of power, was born June 28, 1857, at Ithaca, N. Y., and died November 11, 1913. He received his early education in the public schools of Ithaca, and was graduated in the class of 1884 from Sibley College, Cornell University. From 1884 to 1890 he worked on the design of an automatic horse-drawn hay rake, perfected inventions in carriage springs, and also worked as solicitor of patents. He was inventor of the Morse thermo gage, an instrument for measuring the temper of steel, which had been adopted by the United States and German Bureaus of Standardization. Mr. Morse took a profound interest in public affairs and welfare, and was recently elected president of the Ithaca Hospital Association. He was also a member of the building committee of the new Ithaca City Hospital.

EDGAR PENNY

Edgar Penny, for many years connected with the ice machine and steam engine industry in Newburgh, N. Y., as well as the work of the Alberger Condenser Company, died in Auburn, N. Y., November 14, 1913. He was born in Port Jervis, N. Y., February 13, 1845, and came to Newburgh when a boy to learn the trade of machinist in the Highland Iron Works. When the Civil War broke out he enlisted in the United States Navy and saw service in the South. At the close of the war he continued on the warship as assistant engineer and visited Japan, China and other foreign ports. After three years he returned to Newburgh to take up his work with the Whitehill Engine and Pictet Ice Machine Company. He remained with this company for a few years and then went to Waynesboro, Pa., where for twelve years he was managing director and mechanical engineer of the Frick Company. That firm built an ice machine invented by Mr. Penny, which was known as the "Frick" or the "Eclipse." In 1895 he returned again to Newburgh and formed the Newburgh Ice Machine Company, of which he became the first president. A few years ago when the late Louis R. Alberger bought out the Newburgh Ice Machine and Engine Company, known later as the Alberger Pump and Condenser Company, Mr. Penny became its vice-president, retaining at the same time his position as general manager of the old company. Recently his duties had been lightened when he was made consulting engineer of his company.

HENRY SHOTWELL WOOD

Henry Shotwell Wood, one of the foremost consulting engineers on hydraulic dredging machinery in the country, was born in Philadelphia, Pa., December 18, 1860. He was a graduate of Swarthmore College in civil engineering in the class of 1883, and until 1885 acted as inspector of drawbridge machinery for the Pennsylvania Railroad. From 1887 to 1906 he was designer and inspector of a special contractors' plant for the San Francisco Bridge Company, at the same time designing and building hydraulic dredges for the New York Dredging Company and the Atlantic, Gulf and Pacific Company. Among the largest dredges that he designed and built were the 23-inch suction dredges, Manila and Geo. W. Catt, the 22-inch dredges, Washington and Julia, and the 20-inch dredges, Florida, Port Royal, Texas City, Champlain and Fort Edward. He was the engineer and eastern agent of the North American Dredging Company of California.

Mr. Wood was a member of the American Society of Civil Engineers. He died December 5, 1913.

COMPARATIVE TESTS OF THREE TYPES OF BEARINGS

BY CARL C. THOMAS,[1] BALTIMORE, MD.

Member of the Society

E. R. MAURER[2] AND L. E. A. KELSO,[3] MADISON, WIS.

Non-Members

THIS paper, here published in abstract, reports experiments made to determine the absolute and relative amounts of power required to drive a series of uniformly loaded and flexibly connected shafts supported successively by 20 ring-oiled babbitt bearings, then by 20 roller bearings, and finally by 20 ball bearings. A great range of loads and speeds was covered, and coefficients of friction were worked out for each type of bearing. The apparatus was designed and built in the department of steam and gas engineering at the University of Wisconsin, in collaboration with the manufacturers of the bearings, and was so arranged that very exact measurements of power were attainable. All questions of possible lack of alignment, non-uniformity of loading, temperature and quality of lubricant, etc., were given careful study, resulting in the special form of apparatus used. The tests extended over four years, and were finally repeated and all results checked by a set of skilled observers who had formerly had no connection with the work.

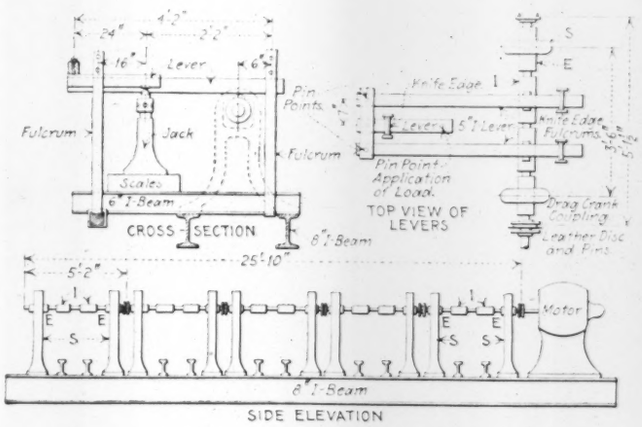


FIG. 1 APPARATUS FOR TESTING LINESHAFT BEARINGS

FIG. 2 VIEW SHOWING METHOD OF LOADING BEARINGS

DESCRIPTION OF APPARATUS

The apparatus consists of 25 ft. 10 in. of lineshafting in five equal sections, mounted in hangers S which were inverted and used as floor stands, (see Fig. 1). The hangers were bolted to two 8-in. I-beams. The shafts are of cold rolled steel, 2 7/16 in. in diameter. Each section is 5 ft. 2 in. long; the adjacent sections were coupled together by means of a flexible leather disk or two straps connecting the two flange couplings. The flexible couplings prevented transmitting any part of the load applied on one shaft to either adjoining section, and also prevented binding between shafts and bearings due to possible lack of alignment.

A direct-current Fort Wayne motor is directly connected to one end of the shafting by means of a flexible coupling. The motor is of the interpole type with the interpoles removed, making it a shunt motor. A water rheostat is used in the field circuit to maintain a constant field, and another water rheostat is used in the armature circuit to vary the speed by varying the impressed voltage. The lost power was obtained first by taking the armature resistance for various currents and plotting a resistance, armature-current curve. From this curve was plotted an armature-I^2R loss, armature-current curve. From this the armature resistance loss for any armature current was obtained. The stray-power loss was obtained by taking a stray-power loss, field current curve for each speed. Then for any speed the loss for that speed and field could be obtained. By use of this method the power required to run the motor alone at all speeds, without load, was accurately ascertained, as well as the power required to run the motor and shafts together, at all loads and speeds. The relative amounts of power required to overcome the friction of the various types of bearings were therefore accurately determined.

[1] Professor of Mech. Engrg., Johns Hopkins University.
[2] Professor of Mechanics, University of Wisconsin.
[3] Instructor in Elec. Engrg., University of Wisconsin.

Presented at the Annual Meeting, 1913, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Pamphlet copies of the complete paper may be obtained: price, 15 cents to members, 30 cents to non-members.

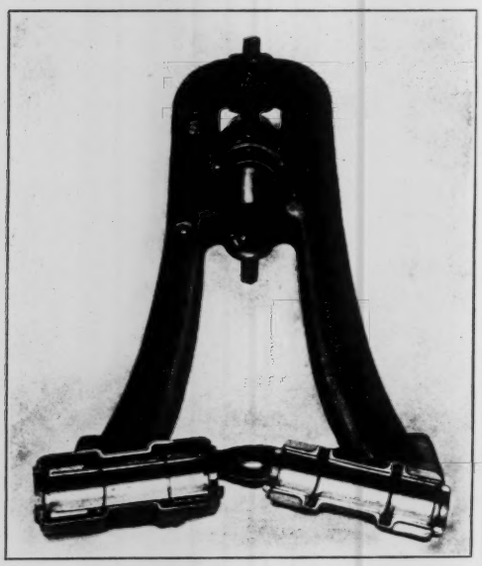


Fig. 3 Type of Ring-Oiled Babbitt Bearing used in Tests

The load was applied through levers upon hardened knife edges and pin points as fulcrums. Across the top of the 8-in. I-beams and at right angles to them were bolted short 6-in. I-beams to which the fulcrums were attached, Figs. 1 and 2.

The loads were applied to the shaft by two bearings between each pair of hangers. These bearings are identical with those in the hangers, and are supplied with knife edges which engage a V-shaped groove in the 5-in. I-beam levers. The bearings and hangers for each section were symmetrically placed with respect to the middle of the section; therefore, equal loads on the intermediate bearings *I*, produced equal pressures on the end bearings *E*. These latter pressures exceeded those on the intermediate bearings by one-half the weight of the shaft, or by 40 lb. This difference is regarded as negligible in the paper, and load per bearing means average of the loads on intermediate and end bearings. The bearings were prevented from turning by short levers fastened to the bearings and resting upon uprights from the floor. Only one type of bearing was tested at a time, so that no complications might arise in establishing the losses for the particular bearing under test. The reason for using 20 bearings was that the amount of power necessary for a single bearing was so small as to be difficult of exact measurement. Also any single bearing might not as truly represent results from that type of bearing in general as several bearings taken together.

The three kinds of bearings tested were: the ring-oiled bearing manufactured by The Dodge Manufacturing Company lined with babbitt metal made from their formula; the Hyatt roller bearing manufactured by the Hyatt Roller Bearing Company; and the Hess-Bright ball bearing manufactured by the Hess-Bright Manufacturing Company. All bearings were for the same size shaft and in fact the same pieces of shafting were used for all the tests, except that two sections which bent during the tests were replaced.

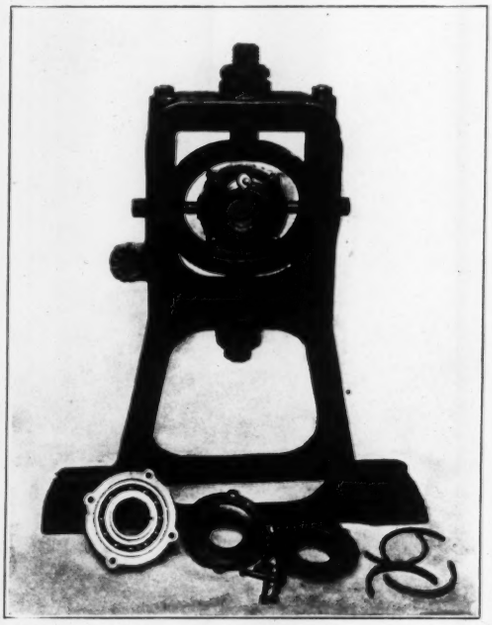


Fig. 5 Type of Ball Bearing used in Tests

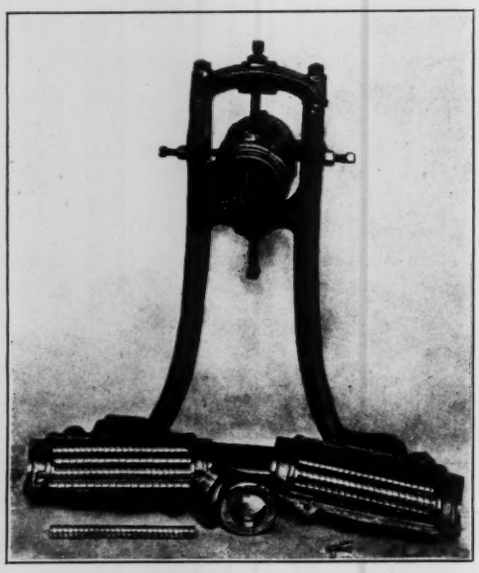


Fig. 4 Type of Roller Bearing used in Tests

The babbitt bearings are 9 $^{21}/_{32}$ in. long and hence their projected area is 22.36 sq. in. The following table is appended here for converting total loads used in the tests into unit loads:

730	1230	1730	2230	lb. per bearing
33	55	78	100	lb. per sq. in.

These bearings were oiled by the well-known ring oiler device, two rings in each bearing.

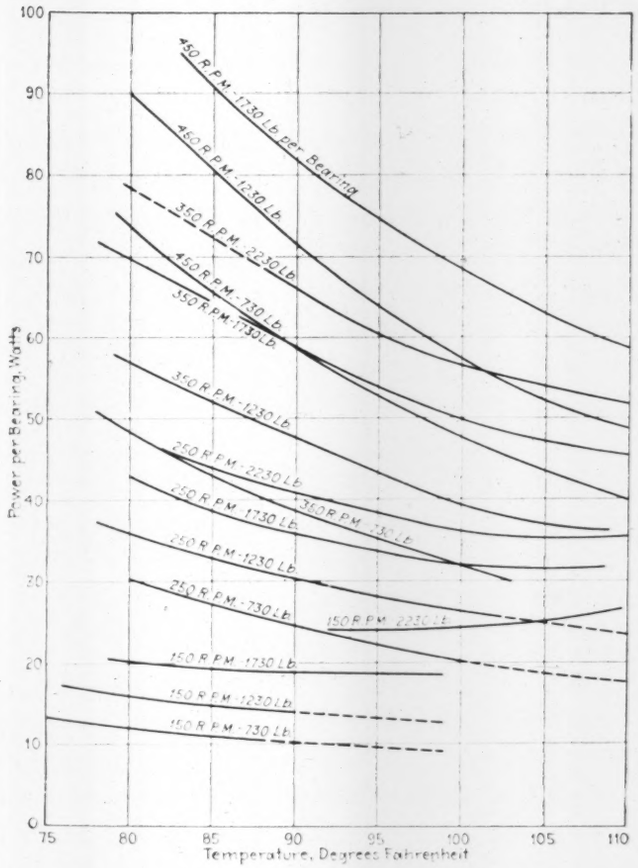


FIG. 6 BABBITT BEARINGS. POWER-TEMPERATURE CURVES FOR VARIOUS SPEEDS AND LOADS PER BEARING

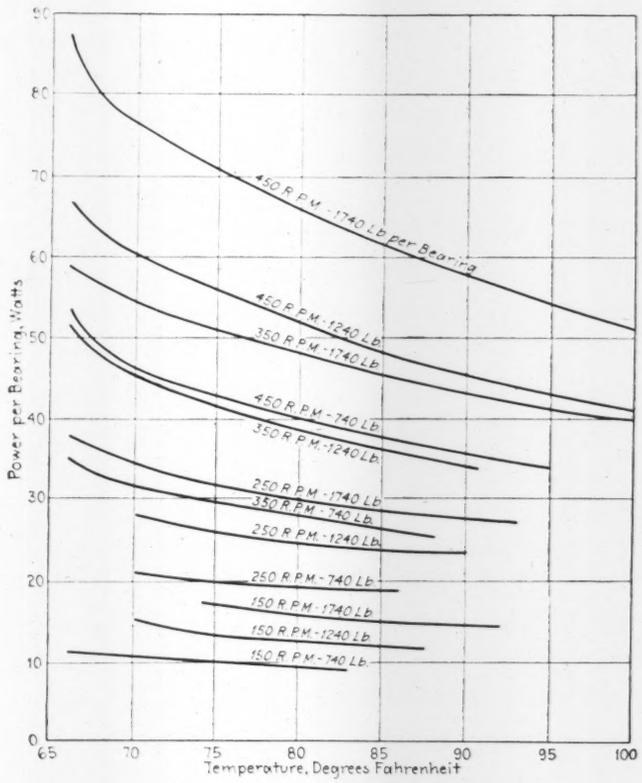


FIG. 7 ROLLER BEARINGS. POWER-TEMPERATURE CURVES FOR VARIOUS SPEEDS AND LOADS PER BEARING

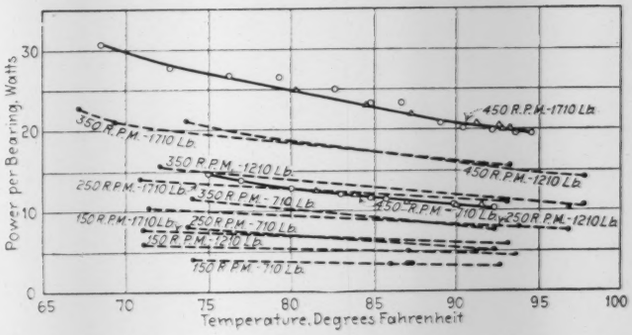


FIG. 8 BALL BEARINGS. POWER-TEMPERATURE CURVES FOR VARIOUS SPEEDS AND LOADS PER BEARING

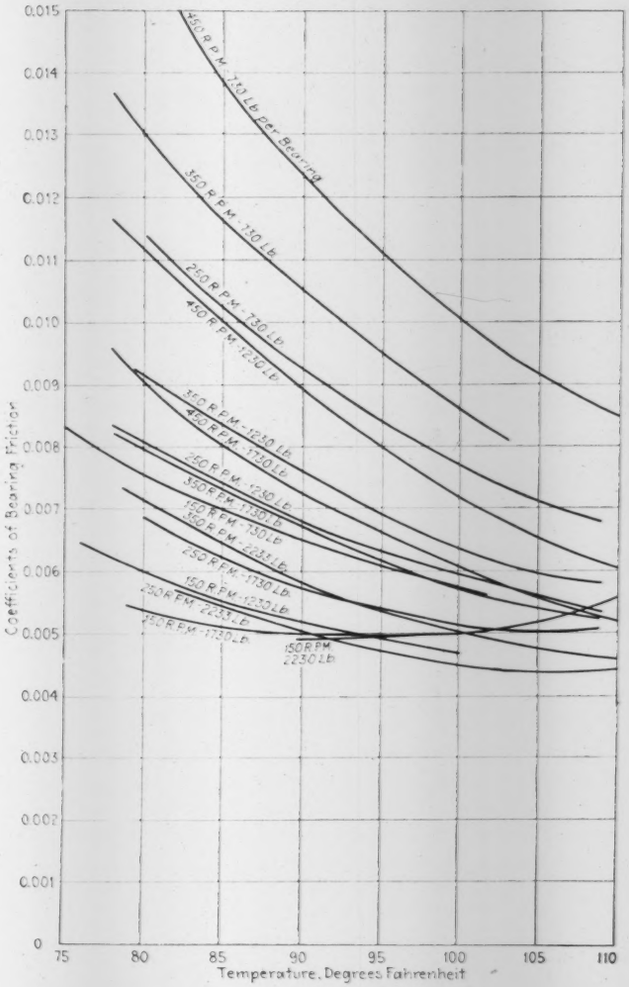


FIG. 9 BABBITT BEARINGS. COEFFICIENT OF FRICTION-TEMPERATURE CURVES FOR VARIOUS SPEEDS AND LOADS PER BEARING

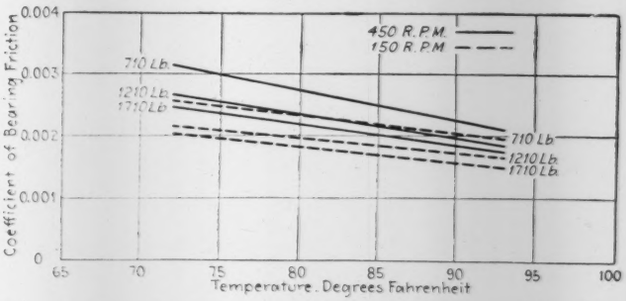


FIG. 10 BALL BEARINGS. COEFFICIENT OF FRICTION-TEMPERATURE CURVES FOR VARIOUS SPEEDS AND LOADS PER BEARING

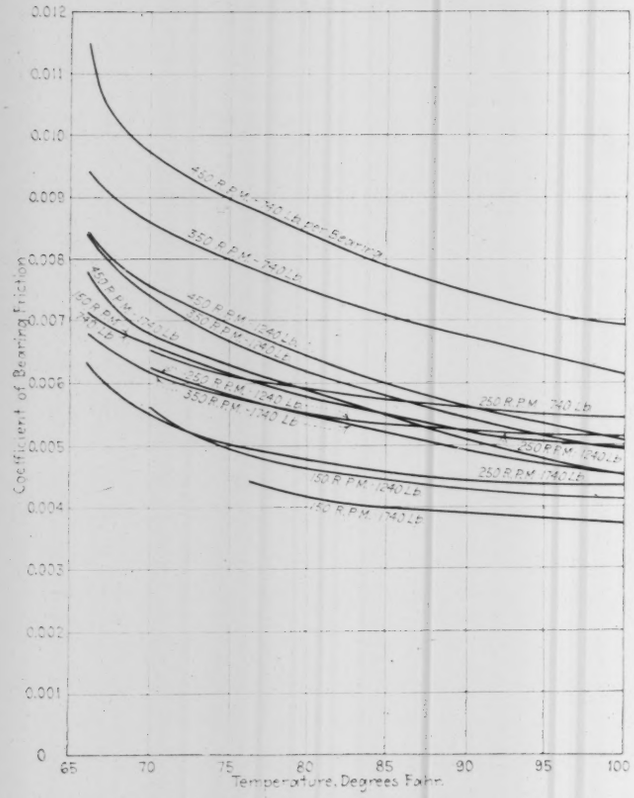


FIG. 11 ROLLER BEARINGS. COEFFICIENT OF FRICTION-TEMPERATURE CURVES FOR VARIOUS SPEEDS AND LOADS PER BEARING

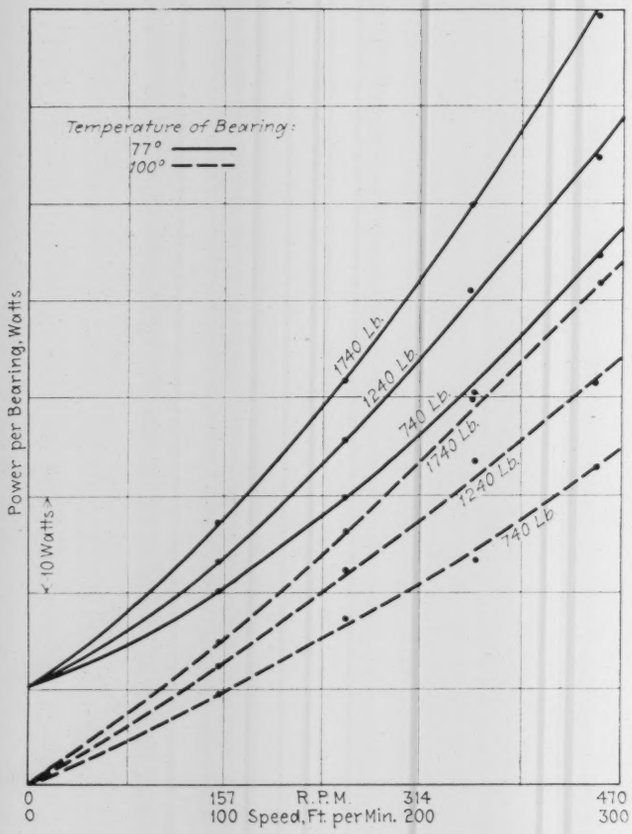


FIG. 12 ROLLER BEARINGS. POWER-SPEED CURVES FOR VARIOUS LOADS PER BEARING

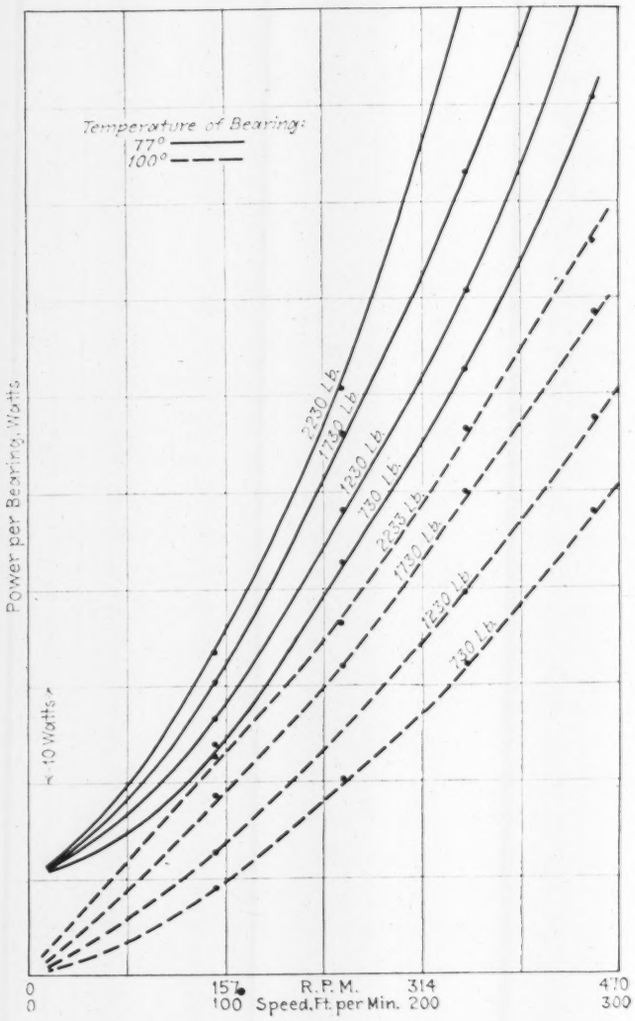


FIG. 13 BABBITT BEARINGS. POWER-SPEED CURVES FOR VARIOUS LOADS PER BEARING

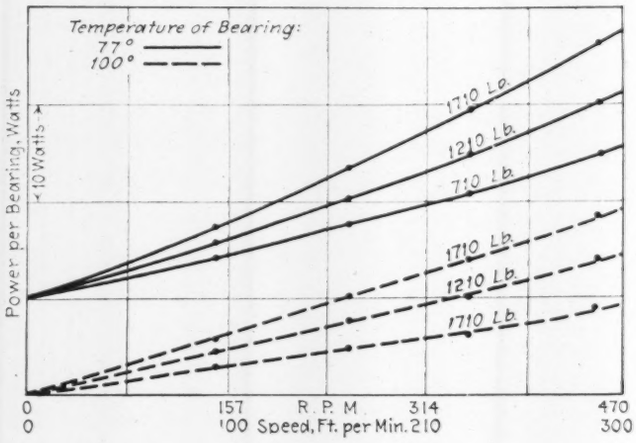


FIG. 14 BALL BEARINGS. POWER-SPEED CURVES FOR VARIOUS LOADS PER BEARING

Each roller bearing contains six right-hand and six left-hand rollers, 0.780 in. in diameter; six are 9 9/16 in., and six are 9 3/16 in. long. The bearings are of the type in which a cage is used for holding one-half the rollers. Each ball bearing contains a single set of balls 9/16 in. in diameter. The diameter of the inner race through ball groove is 3.4729 in. The three types of bearing are shown in Figs. 3, 4 and 5.

The power was measured by the ammeter voltmeter method. Mercury thermometers (two in each babbitt and roller bearing and one in each ball bearing) were used for measuring the temperature of the oil or bearing.

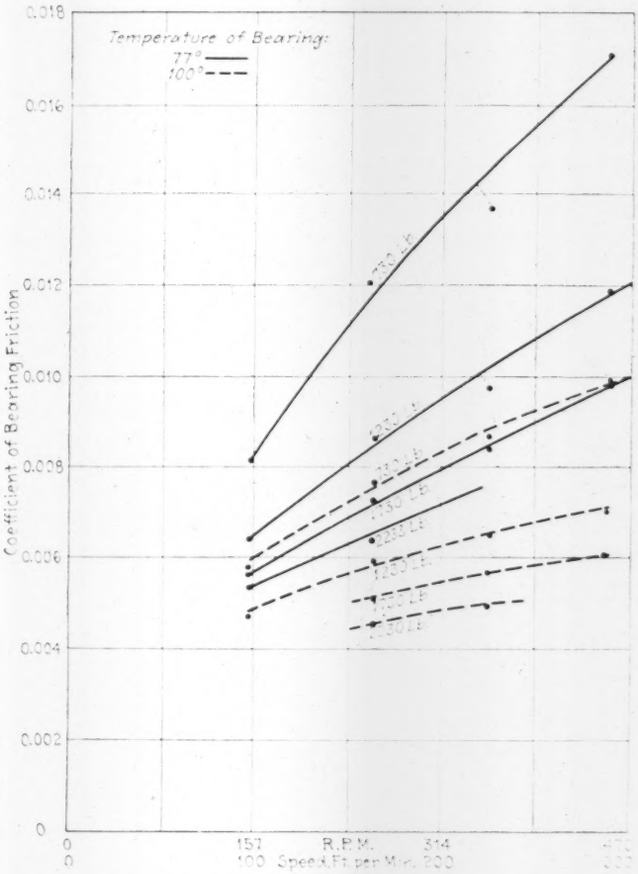


Fig. 15 Babbitt Bearings. Coefficient of Friction-Speed Curves for Various Loads per Bearing

The speeds used in the tests were between 150 and 450 r.p.m., corresponding respectively to about 100 and 300 ft. per minute peripheral speed. Most of the loads used were between 700 and 1800 lb. per bearing, corresponding respectively to about 30 and 80 lb. per sq. in. for the babbitt bearings. All statements of results therefore are subject to the above limitations as to speed and loads, the curves of certain of the figures, however, being extended.

Two lubricants were used in all the tests: Atlantic Red Engine Oil in the babbitt and roller bearings, and No. 2 Keystone Grease in the ball bearings.

RESULTS OF TESTS

Figs. 6, 7 and 8 exhibit the first or immediate results of the tests and show how the power per bearing varied with the temperature at different loads and speeds. The solid lines represent continuous runs and the dotted lines results obtained by dropping either the load or the speed and continuing the run at the previously existing temperature. For all conditions of load and speed the power decreased with increase of temperature, but the rate of decrease at the highest load and speed was not so marked as in the case of the babbitt bearings. At the lower speeds the power did not vary at all with the temperature, practically speaking.

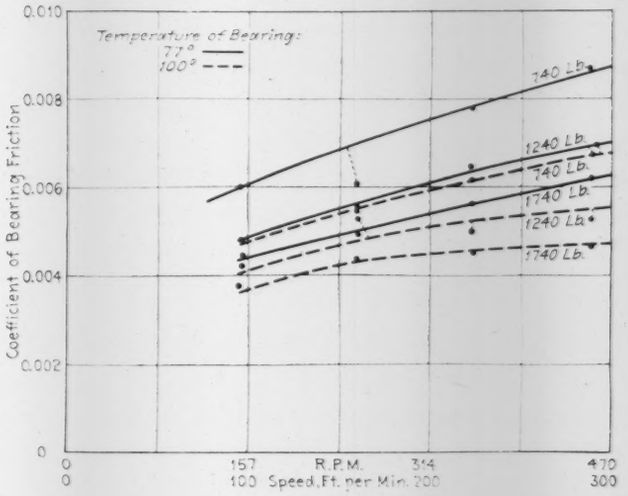


Fig. 16 Roller Bearings. Coefficient of Friction-Speed Curves for Various Loads per Bearing

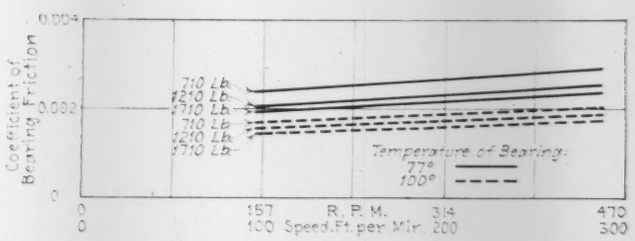


Fig. 17 Ball Bearings. Coefficient of Friction-Speed Curves for Various Loads per Bearing

Figs. 9, 10 and 11 show the coefficient of friction-temperature curves for the three kinds of bearings respectively. The coefficient for roller and ball bearings was computed just as for babbitt bearings from the formula

$$f = \frac{\text{(watts per bearing) } 531}{\pi d n \text{ (load per bearing)}}$$

where f is the coefficient, d the diameter of shaft in inches, and n is the number of revolutions per minute, 1 watt being equal to 44.26×12 or 531 in-lb. per min.

Fig. 12 shows power-speed curves for the roller bearings at 77 deg. and 100 deg. temperature; Fig. 13 the

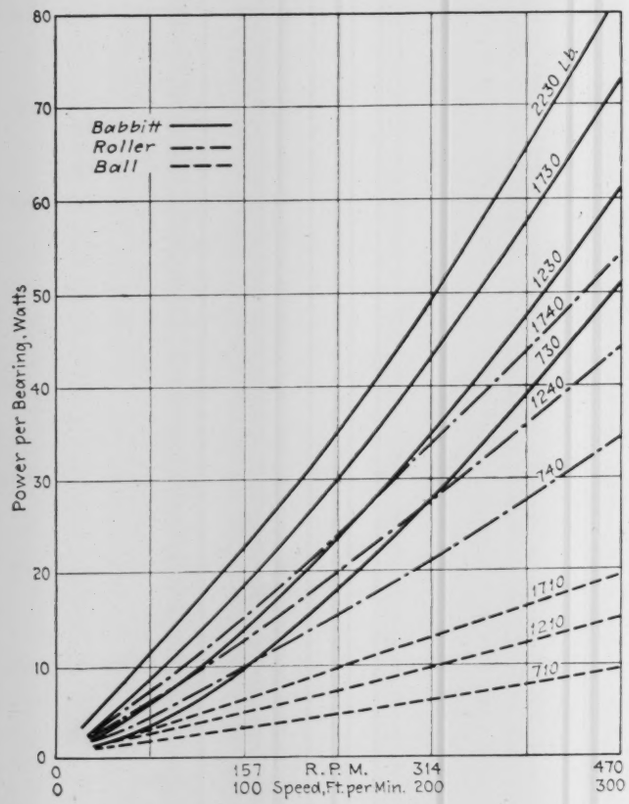


FIG. 18 COMPARISON OF POWERS CONSUMED BY FRICTION IN THE BABBITT, ROLLER AND BALL BEARINGS, AT LOADS PER BEARING AS INDICATED AND VARIOUS SPEEDS; TEMPERATURE OF BEARING, 100 DEG. FAHR.

same for babbitt bearings; and Fig. 14 for ball bearings.

TABLE 1 RELATIVE AMOUNTS OF POWER CONSUMED IN FRICTION

Bearings	100 Ft. per Min.		300 Ft. per Min.	
	77 Deg.	100 Deg.	77 Deg.	100 Deg.
Ball	1	1	1	1
Roller	2.2	2.5	2.7	3
Babbitt	3	3.6	4.5	4

Fig. 15 shows the coefficient of friction-speed curves for babbitt bearings; at 77 deg. and 100 deg. temperature; Fig. 16 those for roller bearings; and Fig. 17 for ball bearings.

Figs. 18 and 19 show a comparison of the babbitt, roller and ball bearings for 100 deg. and 77 deg. respectively. Each curve gives the power required per bearing of the kind indicated to run the shaft under the load and speed indicated. Both figures show that the power for the babbitt is higher than for the other bearings except perhaps at low loads and speed, and that the power for rollers is higher than for balls. The excess of power for babbitt over rollers and rollers over balls increases with increase of speed for all loads. Table 1 shows the relative amounts of power consumed in friction by the three kinds of bearings at the speeds and temperatures indicated; the relative numbers are based in each case on the average power for three loads: 710, 1210, and 1710 lb. for balls; 740, 1240, and 1740 for rollers; and 730, 1230, and 1730 for babbitt.

Fig. 20 shows a comparison of rise of temperature for the three kinds of bearings. Curves *A* and *B* were obtained from simultaneous tests on 8 babbitt and 12 roller bearings. The room conditions therefore as well

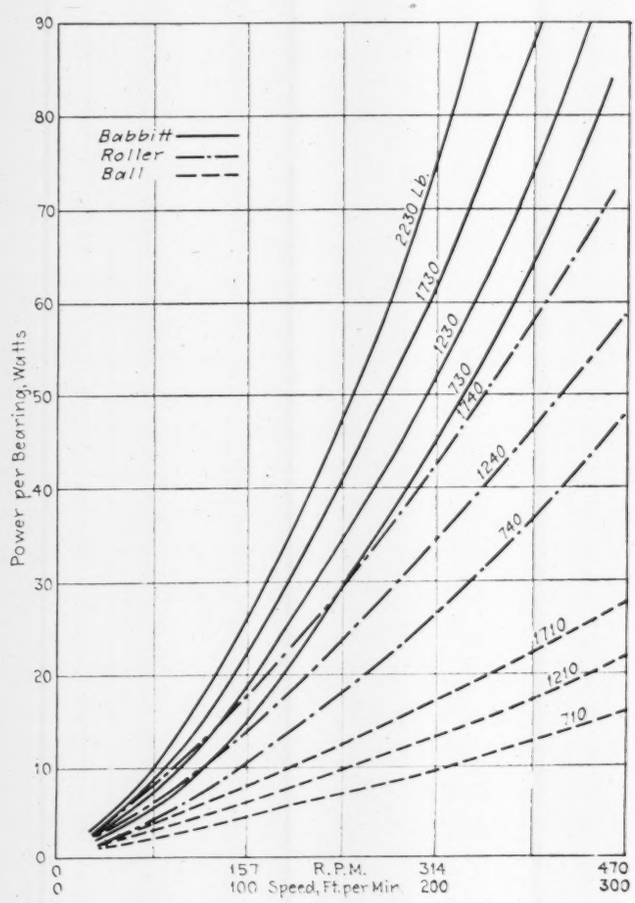


FIG. 19 COMPARISON OF POWERS CONSUMED BY FRICTION IN THE BABBITT, ROLLER AND BALL BEARINGS, AT LOADS PER BEARING AS INDICATED AND VARIOUS SPEEDS; TEMPERATURE OF BEARING, 77 DEG. FAHR.

as load and speed were identical for both kinds of bearings. Curves *C* and *D* were obtained from simultaneous tests on 12 roller and 8 ball bearings respectively.

BREAKDOWN TESTS

In order to observe the performance of the bearings under extraordinarily heavy loads, breakdown tests

were run on each type of bearing with only one section of shafting on which were four bearings. This small number of bearings was used because it was impracticable to keep close watch of a larger number of bearings and avoid trouble during the excessively severe conditions. The maximum load was 600 lb. on the scales, or about 5000 lb. per bearing.

The results are shown in Fig. 21. The speed of 200 r.p.m. was chosen because it represents about the average lineshaft speed in practice. These tests began at

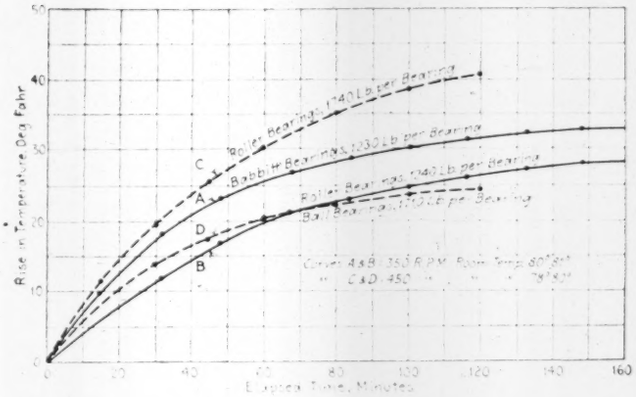


FIG. 20 RISE IN TEMPERATURE. DIFFERENT KINDS OF BEARINGS UNDER PRACTICALLY IDENTICAL CONDITIONS

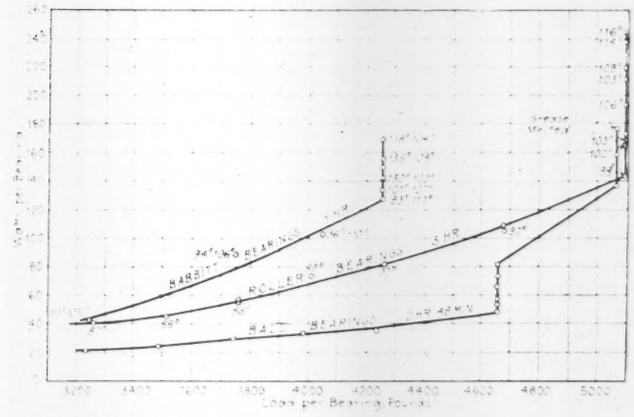


FIG. 21 BREAKDOWN TESTS, 200 R.P.M., 128 FT. PER MIN.

about 3200 lb. per bearing. Failure occurred at about 4250 lb. per bearing in the case of the babbitt, 4650 lb. in the case of the ball bearings, and about 5100 lb. in the case of the roller bearings. The quality and amount of lubricant used undoubtedly have an important effect upon the load that will cause a given bearing to fail.

The bearings did not in any case "fail" structurally, as the power was cut off soon after distress was manifested, but the failure was simply that of the lubricant. Breaking down of the lubricant results in an immediate increase of the power required to maintain the original speed of rotation of the shaft in the bearings. In each case probably only one of the four bearings used in the breakdown tests showed distress at any one time. In the case of ball bearings, this was evident as distress was manifested by disintegration of the grease which "melted" and ran out of the bearing. This was accompanied by the immediate increase in power requirement, as shown in Fig. 21. The temperatures given (99 deg.-117 deg., etc.) indicate the averages for the four bearings being tested. Similar behavior on the part of the babbitt and the roller bearings indicated that at least one of the four under test was suffering from an approach to "metal-to-metal" contact. The bearings were not injured by these endurance tests, and all were used in subsequent tests at the more usual speeds and pressures.

DISCUSSION

E. H. AHARA (written). This paper is of vital interest to every manufacturer, and will be a decided addition to our engineering literature on this most practical subject. It would be most desirable if our universities could be induced to take up and work out scientifically many of these problems which are constantly confronting the manufacturers of the country who have neither the time, equipment nor staff to handle them except in a very limited way.

In connection with this subject, I have been unable to find anywhere the ratio in heating value between the speed of rotation of a shaft, and pressure per square inch of projected area. Many times a question of the limit of a bearing's ability to carry a load at a high speed of rotation becomes of much more importance than the exact efficiency of the bearing from a power standpoint. John Harper, Mem. Am.Soc.M.E., told me of a case of this kind in which by exceeding the limits of all known authorities on some large babbitted bearings, he was enabled to save nearly a quarter of a million dollars in installation charges.

I notice on the lower pressures, as given in the paper, there is but slight variation in power consumed between the three types of bearings. This would be the case in ordinary practice as the usual shaft transmission bearing of $2\frac{7}{16}$ in. in diameter has less than 500 lb. weight to support.

A babbitted transmission bearing usually has the pressure applied to it in a downward direction or at an angle downward and sidewise (sometimes horizontal) and but rarely upward. They are, therefore, usually designed and oiled for a downward pull, and oil is fed from the top of the liner, as in the babbitted bearings under discussion. It will be noticed that the temperature of the middle bearings of the babbitted type in the university test heated much more rapidly than the end ones. This was undoubtedly caused by the pressure being upward against the cap of the bearings instead of downward on the liner. I have no doubt that in the breakdown test Professor Thomas found the first distress came in a center bearing, and that the average rise in temperature of all the tests were markedly increased by the center bearings where heavy pressures were used.

In some tests made in 1907 by the writer at the plant of the Dodge Manufacturing Company, Mishawaka, Ind., the apparatus was arranged so that the pressure was downward on the test bearing, it being placed between two bearings which took the upward pressure and thus having but half

the load of the test bearing. The test was undertaken to determine the limit of power and speed at which these same babbitted bearings as spoken of in the paper under discussion could be run before the film of oil would no longer stay between the babbitt and the shaft. After much preliminary work a speed of 2200 r.p.m. was settled on, giving a peripheral shaft travel of 1404 ft. per min., and the pressure was gradually increased until the practical limit of the oil was reached; the temperature was measured as in method No. 4 of the paper. None of the bearings were run to destruction; the test at 2200 r.p.m. and a definite pressure being continued until there was no further rise in temperature, when a higher pressure was taken. Different grades of babbitt were used to line the bearings, the oil in all cases being Atlantic red.

Pure lead was tested up to 100 lb. per sq. in. of projected area with a temperature of 292 deg. fahr.; pure tin to 124 lb. with a temperature of 276 deg. fahr.; genuine babbitt with a composition of copper four parts, tin 89 parts, antimony seven parts, reached a pressure of 124 lb. with a temperature of 282 deg. fahr.; and a composition of copper two parts, tin 40 parts, antimony 14 parts and lead 44 parts, reached 144 lb. with a temperature of 290 deg. fahr. A composition of tin five parts, antimony 17 parts and lead 78 parts, reached 83 lb. with a temperature of 298 deg. fahr., and a composition of antimony 15 parts and lead 85 parts reached only 62 lb. with a temperature of 314 deg. fahr. At low pressure no appreciable difference was noticed in the heating values, but in the high pressures the tin-based babbitts with small copper contents were found much superior. In view of these tests I think it would be wise for Professor Thomas to have the babbitt metal of the babbitt bearings analyzed and referred to in the paper.

William Kent regarded the paper as a most valuable contribution to the literature on friction, but would like to see it supplemented with results so illustrated that they would be more immediately available to engineers in designing. For example, referring to Table 1, the relative amounts of power consumed in friction, Mr. Kent would like to have seen that table extended to show what relation the amount of power consumed in friction was to the power transmitted. What designers would like to know are the limitations of load and speed for bearings of different kinds, such as ball bearings, roller bearings, and babbitt bearings, with different kinds of lubricants; in other words, the results of this investigation should be put into convenient form for designers.

Selby Haar, referring to the coefficient of friction as it changed with time of operation, asked whether Professor Thomas had any figures as to the coefficient of friction at the actual moment of starting. That was frequently quite an important thing to know in determining the torque of motors or other apparatus which drives a lineshaft and machinery connected to the shaft. He believed that the ratio of initial to final coefficient of friction was frequently much larger than was given by Professor Thomas.

The Author. Replying to Mr. Kent's question, the curves in Figs. 9 to 19 give the relative and absolute amounts of power required by the various bearings, over the whole range of loads and speeds covered in the tests, and also coefficients of friction under all conditions obtained in the tests. Table 1 is not intended to give more than a few figures, taken from the curve, so as to present a general idea of the relative power consumption of the three types of bearing.

Mr. Haar's question as to change of coefficient of friction with time after starting, and its value at starting, is answered, at least in part, by the curves in Figs. 22 to 25 inclusive (shown only in the complete paper).

Regarding Mr. Ahara's question, as to the loading of the two center bearings on the cap instead of on the bottom of the bearing, the design of the babbitt bearings, with respect to lubrication, made it necessary to apply the load in the manner described. On each section of shaft, two bearings were thus loaded on the bottom and two on the cap. The extent of surface of babbitt was the same in the two cases, and the possible unequal distribution of the lubricant would seem to be the principal disadvantage involved. In the breakdown tests the two center bearings did heat more extensively than did the end bearings, and very probably for the reason mentioned by Mr. Ahara, and referred to in the paper. In the breakdown tests the bearings were loaded probably to six times the normal working load for such bearings.

There is this to be said, that in practice lineshafts are likely to be loaded from various angles, and the conditions obtaining during the tests, as to direction of pressure, might be duplicated. The writers recognized, however, that from the standpoint of effective lubrication, especially during heavy loads, it would be preferable to carry all loads on the bottoms of the babbitt bearings. All three types of bearing were loaded in the same manner as was the case with babbitt bearings. The regularity of the curves obtained in the tests, and the results of a series of temperature investigations, in which the load per bearing was about 2500 lb., indicate that the lubrication of the bearings was quite satisfactory up to the extreme breakdown loads of from 4000 to 5000 lb. per bearing, represented in Fig. 21. It will be noticed that the unit bearing pressures employed during the regular tests described were not unusually high, being between limits of about 30 and 100 lb. per sq. in. of projected area, for the babbitt bearings. During the breakdown tests the loads at which the lubricant broke down, in the various types of bearing, varied from about 180 to 230 lb. per sq. in., referred to the area of babbitted bearings. The temperatures attained are shown approximately in Fig. 27.

Analysis of the babbitt had not been made up to the time of writing this paper, but will be made and reported at a later date. It is planned to extend the work so as to include other features of performance, including the question of ultimate time of endurance under the working conditions found in practice.

PITOT TUBES FOR GAS MEASUREMENT

By W. C. Rowse, New York

Member of the Society

ABSTRACT OF PAPER[1]

A series of experiments has been made by the author at the laboratories of the University of Wisconsin to obtain information concerning the reliability of the pitot tube as a means of measuring gases and to determine the accuracy of various forms of the instrument which are in common use. All tubes were compared with a Thomas electric gas meter which was taken as a standard of measurement. Since any variation in results would be due to a wrong method of obtaining the static pressure, simultaneous readings were taken of velocity heads as shown by the pitot tube using the pitot static pressure and by the pitot dynamic tube and a piezometer. The pressure as obtained by the piezometer would not be affected by the form of tube used.

The apparatus used in the experiments is shown diagrammatically in Fig. 1. A Sirocco fan driven by a direct-current shunt-wound motor forces air through the Thomas meter into a galvanized iron pipe 12 in. in diameter in which the pitot tube is inserted. Variable resistances were placed in series with both the field and the armature of the motor, making possible a wide variation in speed. Screens were inserted at the points shown in order to break up eddies and whirls and to have the air flow as nearly parallel as possible at the point where the pitot readings were taken.

The experimenter was stationed directly under the pitot tube and all readings were taken at this point. A mercury barometer, hung on the adjacent wall, gave the atmospheric pressure, and a manometer inclined at a 10 to 1 slope made it possible to determine accurately the static pressure in the pipe above atmosphere. The dry-bulb thermometer indicated the temperature of the air flowing in the pipe and together with the wet-bulb thermometer gave readings from which the humidity could be determined.

The pitot tube is a well-known measuring instrument and needs only a brief description. It consists essentially of two parts: a dynamic tube pointing upstream which converts the sum of the pressure energy and the velocity energy into a head which may be measured; and a means of determining the pressure head (or static pressure) alone. The difference between the dynamic head and the static pressure head is the velocity head h in the fundamental formula for the flow of fluids

$$v = \sqrt{2gh}$$

It has been satisfactorily proved and accepted that the dynamic tube of a pitot tube gives the correct pressure if the tube points parallel to the current. But it is a very difficult matter to obtain the correct static pressure on account of secondary velocity effects. Therefore the study of the accuracy of the pitot tube resolves itself into a study of the correct method of obtaining the static pressure at the given cross-section where the tube is inserted.

Each pitot tube tested had as a part of the tube a means of determining the static pressure, and readings of the velocity head were obtained by using this pitot tube static pressure. Simultaneous readings of the velocity head were obtained by using a piezometer ring for the static pressure together with the dynamic tube of the pitot tube under test. This is further illustrated by reference to Fig. 1. Manometer B gives the

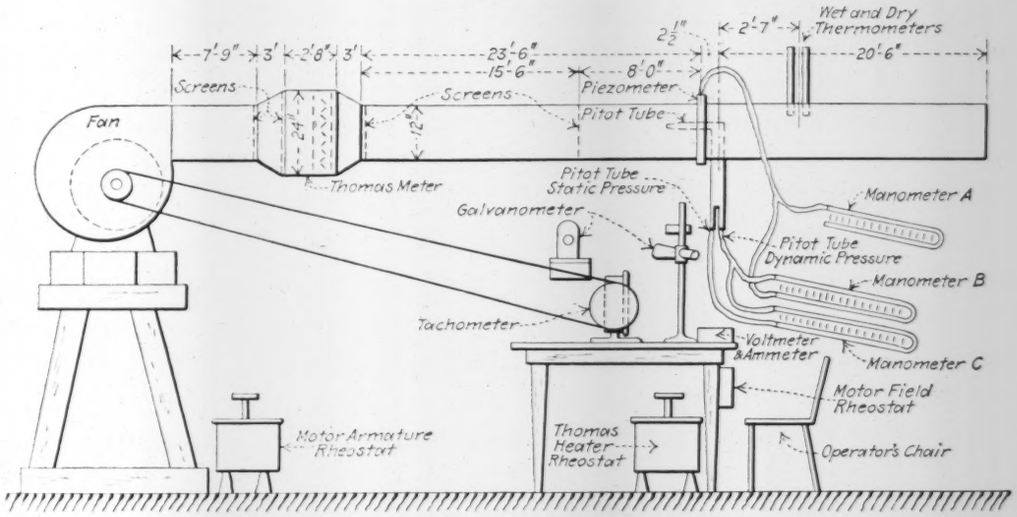


Fig. 1 Sketch of Apparatus

[1] Published in complete form in the September 1913 issue of The Journal of The American Society of Mechanical Engineers, and presented at the annual meeting, December 1913. Pamphlet copies may be obtained: price, 20 cents to members and 35 cents to non-members.

velocity head by using the piezometer static pressure, and manometer C gives the velocity head by using the pitot tube static pressure. In both cases the same dynamic tube pressure is used. This piezometer, even if it were possible to be in error, would always indicate the same pressure under the same conditions irrespective of the tube under test and thus it afforded an additional means of *comparison* independent of the Thomas meter.

The piezometer is shown in Fig. 1 and Fig. 3, and is simply an absolutely air-tight annular space about the pipe, connected with the interior of the pipe by six small holes 0.04 in. in diameter.

A large number of readings was taken across two

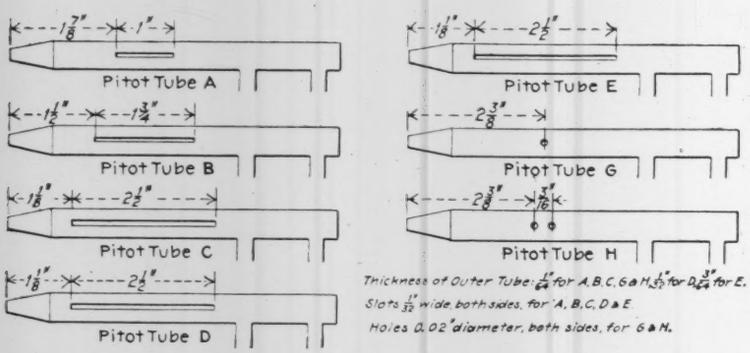


Fig. 2 Sketches of Pitot Tubes A to H showing Dimensions of Static Openings

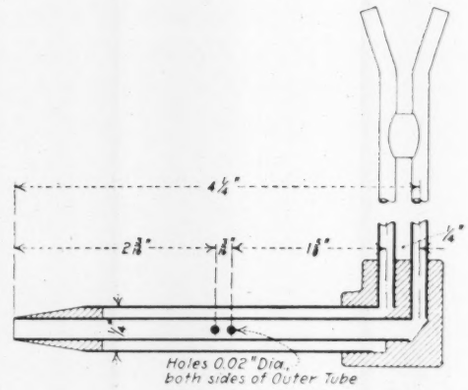


Fig. 5 Pitot Tube Y

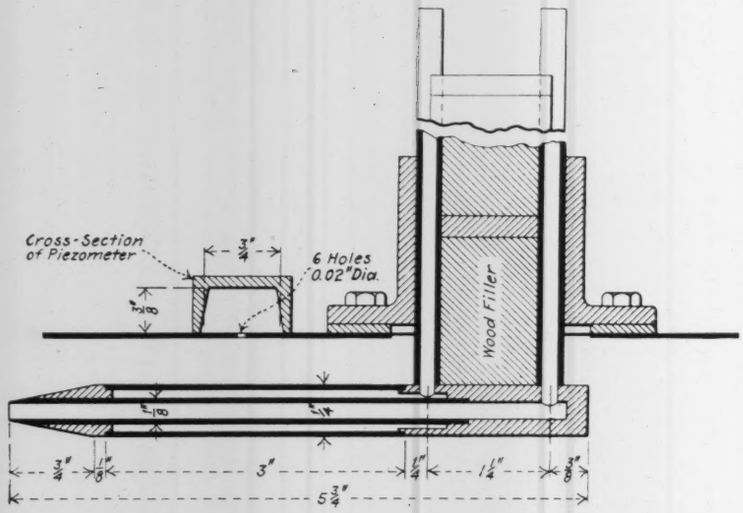


Fig. 3 Dimensioned Sketch of Pitot Tubes A to H

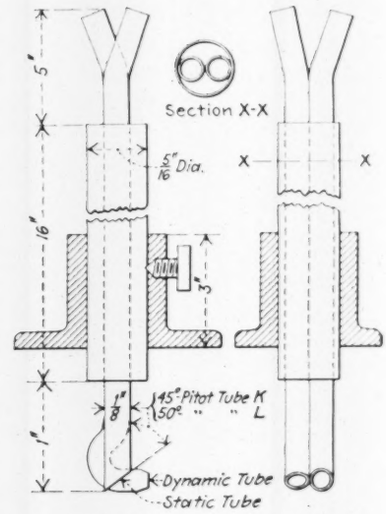


Fig. 6 Tubes K and L

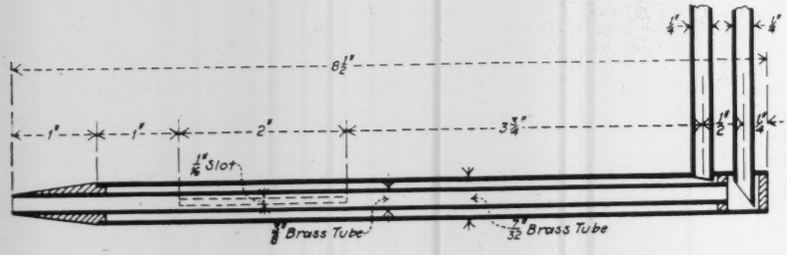


Fig. 4 Dimensioned Sketch of Pitot Tube X

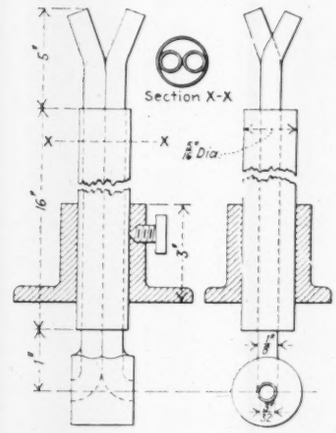


Fig. 7 German Stauscheibe

diameters of the pipe. The total area of the pipe was divided into five concentric annular areas and four readings of the velocity head were obtained in each test at the center of each annular area, thus giving 20 readings from which the mean velocity head could be calculated. Since the velocity varies as the square root of the velocity head it was necessary to average the square roots of each of the 20 readings, and the square of this average represented the mean velocity head.

As to the limits of accuracy, the accuracy of the measuring instruments used is much greater than can be expected from the pitot tube as a means of measuring gases, due to the uncontrollable variation in the air flow. The considerations which may prevent even an absolutely correct pitot tube from giving true results are as follows:

a The air flows through the pipe in a wave or spiral motion and at no time is the velocity uniformly distributed across the pipe, being greater in one quarter than in the other three quarters; the quarter of highest velocities may or may not be on the diameters where pitot tube readings are being taken.

b The velocities on the diameters where pitot tube readings are being taken may be constantly varying during the period of time necessary to obtain the readings; thus the average of all readings may be slightly too large or too small.

c The air flow can only approach, never reach, the ideal conditions of parallel flow, and the pitot tube is correct, theoretically, only when the tube is exactly parallel to the current of air.

From these considerations, together with the author's experience in this line of work, it is estimated that the results obtained in measuring gases by an absolutely correct pitot tube may vary 1 per cent, more or less, from the correct results. Of course, the average of a large number of tests should be more nearly correct than this, for the plus errors will probably neutralize the minus errors.

From a study of the summary of the tests, the following general results and conclusions may be stated:

a The pitot tube as a means of measuring gases is reliable within approximately 1 per cent when the static pressure is correctly obtained and when all readings are taken with a sufficient degree of refinement; in order to obtain this degree of accuracy the pitot tube should be preceded by a length of pipe 20 to 38 times the pipe diameter in order to make the flow of gas as nearly uniform across the section of the pipe as possible.

b All the methods of obtaining the dynamic head used in these experiments, including the Stauscheibe, give accurate results.

c The most reliable and accurate means of obtaining the static pressure is the piezometer or its equivalent, the results of 138 separate tests using the piezometer static pressure agreeing with the Thomas meter within an average of 0.33 per cent; these results show beyond any doubt that the static pressure is constant across any section of a pipe in which gas is flowing at a uniform rate.

d Of the methods of obtaining the static pressure by the pitot tube itself, the most reliable and accurate is by means of a very small hole in a perfectly smooth surface, as in pitot tube *Y*.

e The long slots for obtaining the static pressure are not reliable and give results which are in error from 3.5 to 10 per cent. The length of the slots or the thickness of the outer tube do not appear to affect the accuracy of the tube.

f The beveled tube for obtaining the static pressure as used in pitot tubes *K* and *L* is not reliable. A very slight change in the angle of bevel produces an appreciable change in the result. In taking a traverse of a pipe the sides of the pipe affect the readings. But the greatest error is produced by the uncertainty as to whether the tube is pointing directly upstream. The effect of allowing the tube to point at an angle of 20 deg. off the direction of flow is to introduce an error of 85 per cent in the velocity head.

g The Stauscheibe gives accurate results using either the static reading from the Stauscheibe and the special formula for it; or by using the piezometer static with the usual formula for the pitot tubes. In the first case the agreement is within 1.4 per cent and in the second within 0.16 per cent.

h It appears that an approximate relation exists between the mean velocity head of a gas flowing through the pipe and the velocity head found by placing the tube at the center of the pipe. For a 12-in. galvanized iron pipe results within 2 per cent may be expected from using the formula

$$v = \sqrt{(2g)\,(0.80)\,h_c}$$

where

v = velocity in ft. per second.

g = 32.2 ft. per second per second.

h_c = velocity head at the center of pipe in feet of gas flowing.

DISCUSSION

D. S. Jacobus asked the author whether or not he had determined what happened at the first ordinary point of critical velocity, and whether he had carried the velocity high enough in his experiments to show whether there was a second critical velocity. Apparently, in the use of some steam flow meters there were some peculiar actions when the velocities got up to a very high figure, and there was indication of the possibility of a second critical point.

W. H. Carrier (written). The paper throws light on a source of possible error in the readings of the pitot tube which has been troubling me for some time. Mr. Rowse shows that the impact pressure is not appreciably changed

by an angular deflection of the pitot tube of as much as 15 deg. in either direction. This means that where there is a swirl or turbulence in the air so that the direction of flow at the point of measurement is not parallel to the air duct, that is, normal to the plane of measurement, that there may be a considerable error introduced, since the pitot tube will indicate the relative velocity of swirl in addition to the effectual velocity of flow parallel to the pitot tube. It is also very difficult to get accurately the rapid drop in velocity occurring near the surface of the air pipe or conduit. For these reasons, it will often be found in practical installations that even with a very careful use of the pitot tube, apparent air quantities will be obtained which are 5 per cent or more higher than the actual.

Of course in a laboratory or shop test, as conducted by Mr. Rowse, where comparatively long straight piping is used and special means are taken to insure substantially parallel flow, as well as uniformity of velocity, the results given by the pitot tube will be exceedingly accurate, as his tests indicate. In practical fan installations, however, it is usually impossible to obtain anywhere near such favorable conditions for accuracy of measurement. In about nine cases

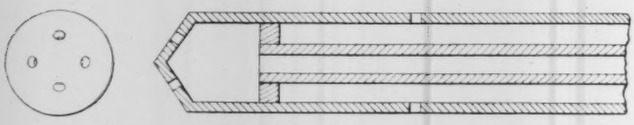


Fig. 8 Special form for Impact End of Tube

out of ten it is necessary to take the measurements either at, or close to, the fan outlet, where there is a great deal of turbulence in flow, as well as a great variation in velocity. In all such cases too great a reliance should not be placed upon the accuracy of the pitot tube.

On account of this inherent source of error in the form of pitot tube advocated by Mr. Rowse, it should be adopted as a standard instrument only until some more reliable and perfect form is devised. Such an improved form of pitot tube should give an impact or differential reading which would vary properly with the angle of deflection of the pitot tube with respect to the direction of velocity; that is, for the accurate integration of effectual velocity in turbulent flow, the effectual velocity pressure should correspond substantially to the following formula at various angles of velocity direction

$$p_e = p', \cos^2 a$$

where P_e = the effectual velocity pressure indicated by the differential gage and pitot tube

P' = the actual velocity of the air at some angle to the tube

a = the angle of deflection of the pitot tube with respect to the actual direction of the air velocity

It would seem quite possible that with some experimentation such a reliable form of pitot tube could be produced. This could be accomplished in either one of two possible ways:

a By constructing the impact member so that it will be sensitive to the change of angle in any direction, as shown in Fig. 8.

b By constructing the static member so that it will increase the static pressure with any change of angle sufficient to compensate for the error in the impact member.

Karl Nibecker asked the author if he had found a critical velocity at which the pitot tube ceased to be accurate. Recently in some work with turbo blowers where the machine was working at high pressure, the only means of discharge for the air was a comparatively small pipe. The velocity in this pipe, where it was necessary to measure the air, exceeded, by a considerable amount, any velocity that had been attained before within the speaker's experience and which had been measured with the pitot tube. It occurred to him, that very probably there was a point where the velocity was such that the pitot tube could no longer be considered an accurate means of measurement, although it has been found to be accurate for low velocities. In the case in question, the pressure was also much higher than ordinarily obtained in pipes supplied by simple fans. The pressure in the line to be measured was about 30 lb. per sq. in. and the velocity was in the neighborhood of from 1000 to 1200 ft. per sec.

C. C. Thomas (written). Referring to *c* under Limits of Accuracy, I understand that this refers to the static pressure only, and that the curves in Fig. 16 (of the complete paper) indicate that the static pressure is constant over the cross-section of the pipe. If the static pressure is measured by use of the piezometer ring, it appears that the dynamic tube may point at quite an angle with the direction of flow without seriously affecting the reading of velocity head. In this connection, it would seem that *f* under Results, should have the words "due to incorrect static readings" added to the last sentence in the paragraph.

Leo Loeb (written). The paper has served to clear up many of the problems connected with the measurement of gases with pitot tubes, but the conclusions reached in regard to the reliability of certain forms of pitot tubes should not seriously question previous tests involving measurements of the flow of air when properly using these forms of tubes.

In the early comparative tests between the Thomas and venturi meters and the Taylor pitot tube, C. C. Thomas reports in a paper[1] that for air velocities between 1500 and 3000 ft. per min., "the pitot, venturi and electric meters will all give accurate and reliable results when properly used under favorable conditions and when observations are taken with a sufficient degree of refinement in method. . . . The close agreement of the results obtained in the measurement of a common quantity by these three fundamental and independent methods of measurements, with independent observations taken for each, forms, from a scientific standpoint, a very interesting proof of the correctness of the several theories involved." The pitot tube used by Professor Thomas is almost the same as Mr. Rowse's type *X*, the slots being respectively 3/64 in. and 1/16 in. wide and in both cases 2 in. long. The general arrangement for test was the same and the fans differed in capacity by the ratio 4:3. It appears strange therefore, that while Mr. Rowse calls attention to an average of 9.87 per cent variation between the electric meter and type *X* tube, he does not attempt to reconcile such results with reports from the same laboratory of an average variation of 0.38 per cent between the two meters.

[1] The Measurements of Gases, Journal of the Franklin Institute, November 1911, p. 411.

The Taylor tube with slots 1/16 in. wide and 2½ in. long was used in the measurement of air delivered through a 12½-in. duct to an air heater tested at the United States Naval Engineering Experiment Station in May 1912. Except for the radiation losses, which were determined by a separate test, the apparatus also formed an air meter of the heater type in which steam was the heating medium. While the object of the test was to investigate the heat transfer of the apparatus, the results furnish a sufficient check on the accuracy of the air measurements to be presented in this connection. All tests were of 30 minutes duration with observations every 5 minutes.

1	Test number	I	II	III	IV
2	Barometer, in. of mercury	30.42	30.38	30.49	30.42
3	Static air pressure, in. of water	0.64	1.91	2.62	3.91
4	Absolute air pressure, lb. per sq. in.	15.05	15.07	15.14	15.16
5	Room temperature, deg. fahr.	71.3	64.3	67.0	58.2
6	Air entering heater, deg. fahr.	37.9	35.9	38.2	39.1
7	Air eaving heater, deg. fahr.	144.8	130.0	128.9	123.8
8	Relaltive humidity entering air	79.9	74.0	66.1	65.1
9	Weight of moist air, lb. per cu. ft.	0.08098	0.08148	0.08151	0.08142
10	Mean specific heat of air, B.t.u., per lb.	0.2477	0.2457	0.2454	0.2452
11	Steam pressure, lb. gage	96.5	96.6	96.5	96.1
12	Steam quality, per cent	0.9879	0.9918	0.9957	1.9 (superheat)
13	Average air velocity by pitot tube, ft. per min	956	1677	1992	2420
14	Lb. of air per min.	66.00	116.43	138.00	168.94
15	Steam condensed per min., lb.	2.050	3.092	3.517	4.058
16	Heat yielded by steam, B.t.u., per min	1792	2710	3091	3591
17	Heat absorbed by air, B.t.u., per min	1748	2691	3072	3508
18	Heater efficiency	0.976	0.993	0.994	0.977
19	Radiation and losses, B.t.u., per min. computed from radiation test	7	7	6	9
20	Pitot tube coefficient	0.980	0.996	0.996	0.980

The above are only four of a series of 20 tests, all of which verified the results that the tube coefficient varied from 0.98 to 1.00. The average velocity was obtained by a traverse on two diameters using 22 points for observations on each diameter.

A form of inclined manometer which has been used with considerable success is shown in Fig. 9. It consists of a U-tube secured in such a way as to permit the two legs to remain always in the same vertical plane at the same time allowing them to take any desired inclination. The scale is a carefully selected sheet of cross-section paper. This manometer uses as a fluid a mineral oil of density 0.825 and forms its own leveling device, since there is visible both a distinct vertical and horizontal meniscus. The horizontal meniscus of the two tubes is leveled to the same horizontal line on the cross-section paper by swivelling the backing board, and readings are taken on the horizontal scale. The net reading multiplied by the inclination and the oil density is the true head. The scale multipliers are 0.2, 0.5 and 1.0, which with a 12-in. tube cover the entire range of pressures encountered with forced draft blowers.

There seems to be a difference of nearly 2 per cent on the average between results with tubes *H* and *Y* although the dimensioned sketches show almost identical proportions, differing only slightly in overall length and lead connections at shank.

There are cases where the Thomas meter could not be used on account of its introducing resistances against which the fan would not operate in practice. An alternate method of measuring the discharge would be a simple outlet nozzle traversed with an impact tube at sufficient points to give an average velocity. It is therefore to be regretted that Mr. Rowse did not combine with his experiments a traverse of the pipe outlet to determine how completely the static pressure was converted into velocity head.

F. R. Still (written). The writer, as a designer and builder of fans and blowers and deeply interested in the subject of air measurement for nearly 30 years, has developed a number of instruments for the purpose, but finally settled on the one designated as pitot tube *Y* in Mr. Rowse's paper. This tube has been calibrated in many different ways, such as whirling it on a shaft and correcting for the

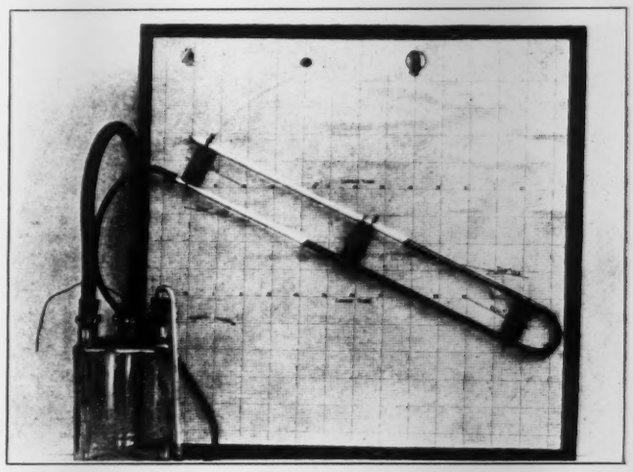


Fig. 9 Inclined Manometer

centrifugal force, by measuring the flow through a tube leading out from a gas holder, and in a pipe in which the flow was simultaneously measured by the Thomas meter. These various comparative tests showed this tube to be less than 1 per cent below the actual velocity. The larger the pipe, the less will be the variation from the actual velocity, as the friction along the walls of the pipe is proportionately less in a large pipe than in a small one.

The particular advantage of the pitot tube is that it is more accurate than any other portable instrument available; in fact, there is no other form of device, either portable or stationary, for measuring accurately large or small volumes at high or low velocities in large or small pipes, which at the same time determines the static pressure or resistance to the flow. The latter is quite as essential to the determination of the work performed as is the determination of the velocity or volume.

The accuracy of the results obtained is largely a measure of the care exercised in the preparation for, and the taking of the readings. The author is correct when he says that the further the readings are taken from the fan the longer will be the spiral or wave of the air as it passes through the pipe. When it is necessary to take readings close to the fan, the cross-section of the pipe should be divided into more and smaller zones so as to get a better average.

The author states further that since the velocity varies as the square root of the velocity head, it was necessary to average the square roots of *each of the* 20 *readings*, and

the *square of this average* represented the mean velocity head. This is unnecessary if the cross-section of the pipe is divided into numerous zones of *equal area;* doing this at first simplifies very much the later computations. For instance, if each zone is of equal area and reasonably small, the average result must be the average velocity of all these areas. But if the pipe is divided into *equal divisions* but of *unequal areas,* then the average of the pressure readings will not give the correct average velocity.

It is indeed very gratifying to note the attention air measurement is receiving of late and the efforts being made to arrive at some standard method of procedure, as well as the design of some simple, standard, portable instrument for such purpose. The thoroughness of Mr. Rowse's investigations and comparisons should establish definitely the best form of pitot tube for accurate results, and not only settle the ever recurring question as to the accuracy of any type, but also settle once and for all the relative accuracy of the different types, which latter has never heretofore been thoroughly established in the minds of but few engineers.

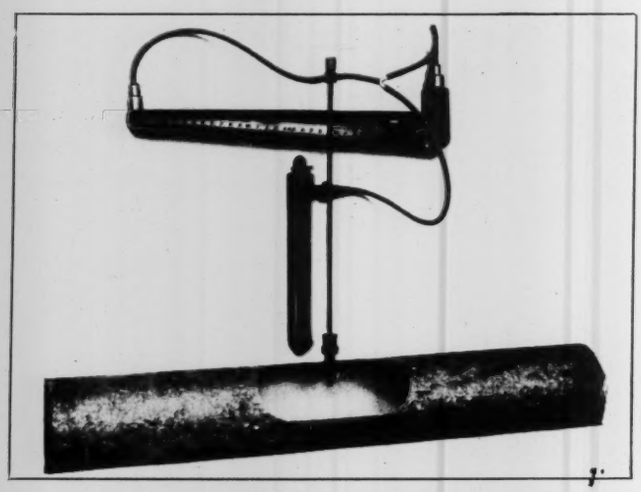


Fig. 10 Tube applied to Circular Conduit

G. F. Gebhardt (written). The pitot tube with beveled-end static opening originated, the writer believes, in the laboratories of the Armour Institute of Technology. At least no information pertaining to this style of tube was available when the first experiments were made in the year 1904. The sole object of beveling the end of the static tube is to permit of a compact, portable construction which may be readily introduced into a conduit through a single small opening. The application of a commercial design of this tube to a circular conduit is shown in Fig. 10.

Mr. Rowse's conclusions that the beveled-end static opening is not reliable, is true only where extreme accuracy is desired. According to his own experiments the *average* departure of the beveled-end pitot tube from that of the pitot tube with piezometer static, which he considers reliable, is less than 0.7 per cent for full gate and a trifle above 0.6 per cent for half gate opening (Table 14 of complete paper). The *maximum* departure is 1.6 per cent for full gate and 1.3 per cent for half gate opening. The average departure from the Thomas meter readings is 1.8 per cent for full gate and 1 per cent for half gate opening. Tests conducted by Mr. Kneeland[1] with tubes furnished by the writer gave results agreeing within 1.5 per cent of volumetric determinations for all velocities up to 8000 ft. per min. Numerous experiments made in the laboratories of the Armour Institute of Technology on 100 or more tubes with beveled-end static openings gave results agreeing within 2 per cent of holder displacements. For most practical considerations this error is well within the accuracy of other factors involved in determining the flow of gases.

Mr. Rowse is to be congratulated upon the thoroughness of his investigations and for having grouped in a convenient form the relative defects of the various types of pitot tubes commonly employed in measuring the flow of gas in closed conduits.

C. P. Crissey (written). Engineers interested in the measurement of air and other gases will find much of value in the Rules for Testing Blowers and Compressors approved by the Verein deutscher Ingenieure in 1912, and published in a pamphlet entitled Regeln für Leistungsversuche an Ventilatoren und Kompressoren. Among other

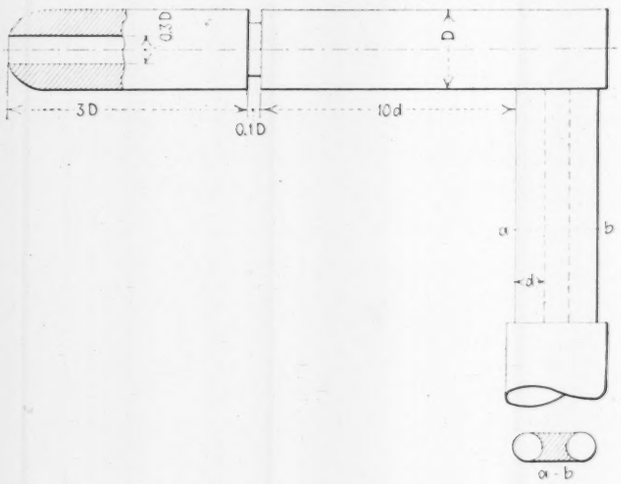


Fig. 11 Prandtl's Tube with Spherical End

things, these rules recommend a tube known as Prandtl's pitot tube. From Fig. 11 it will be seen that this form of tube has a hemispherical head, and a slot extending around the entire periphery. It is stated that a deviation of 15 deg. from the direction of flow has no effect upon the velocity readings, but the static pressure reading is lowered if the deviation is more than a few degrees. Possibly experiments with such a tube will show it has no advantage over some of the tubes so carefully tested and reported upon in this paper, but before a standard tube is adopted it would seem well worth while to investigate the merits of Prandtl's pitot tube.

A. G. Christie (written). Mr. Rowse found that several tubes which had heretofore been regarded as suitable for this work, gave results considerably in error. The care that he took to break up wave action in his test pipe and his comments on this phenomena would indicate that considerable discretion must be exercised in the use of pitot

[1] Trans., Am. Soc. M. E., vol. 33, p. 1155.

tubes for the measurement of air or gases discharged by fans or compressors.

In Europe the method generally used for measuring fan or compressor capacity is to discharge through orifices with well rounded mouths. However, there exists a considerable difference of opinion among English and Continental engineers as to the forms of these orifices, their finish and the discharge factors to be applied to them, in spite of the fact that a committee of the Verein deutscher Ingenieure have published a set of rules for power tests on fans and compressors.

In America many different methods are employed in testing fans and compressors, and up to the present time there have been no recognized standard methods or standard test apparatus. Engineers in both Europe and America employ several different expressions for defining efficiency with as many ways of calculating them. Hence, reports of compressor tests are of little use unless the method of calculating them is also available for inspection.

There is an urgent need of a clear, comprehensive statement of means, methods and apparatus to be used in such tests together with an elaborated definition of the expressions of efficiency.

THE AUTHOR. Dr. Jacobus and Mr. Nibecker have asked questions regarding a critical velocity at which the pitot tube ceases to give accurate readings. No such critical velocity was observed in these tests, the highest velocity reached being about 4500 ft. per min., which was the limit of the apparatus. Tests are now being conducted at the University of Wisconsin with higher velocities and smaller pipes which may provide further information on the subject.

Mr. Carrier's remarks regarding the practical difficulties in accurately measuring fan discharges are very interesting and illustrate the care which must be observed in order to obtain even approximately correct results. Of course, the experiments reported in the paper were conducted under laboratory conditions in order to compare the accuracy of various forms of tubes. The accurate measurement of gases under practical conditions has its own peculiar difficulties, but it is at least something to know that the pitot tube used would give correct results if the conditions were ideal. It is then the engineer's problem to take his readings at such a point and in such a manner as he thinks will give best results.

Mr. Loeb has noted that there is a variation of almost 2 per cent between results obtained by tubes *H* and *Y*, although the tubes are almost identical, which probably represents the possible error of the pitot tube as a means of measuring gases. It would be well to state here that several other tubes of this type have been tested at various times at the University of Wisconsin, using this same apparatus, and in every case the agreement between the pitot tubes and the Thomas meter has been so close as to leave in the author's mind no doubt as to the accuracy of this type of tube.

A close study of the tests reported by Prof. C. C. Thomas in the Journal of Franklin Institute, to which Mr. Loeb has referred, will show that the pitot tube used in those tests had small holes in addition to slots; that insufficient precautions were taken to produce parallel flow at the pitot tube; and, most important, that readings were taken on *one radius* only. The readings thus obtained gave the average velocity for only one-quarter of the pipe cross-section, which in this case gave results agreeing closely with the Thomas meter. If readings had been taken across *two diameters* the agreement might not have been so close. Of course it might be possible to make a pitot tube with slots for obtaining the static pressure which would give correct results, although one could not be sure of this fact unless the tube were calibrated.

In answer to Mr. Still's statement that it is unnecessary to average the *square roots* of the observed velocity heads, when the readings are taken at the centers of equal areas, the following mathematical proof is offered:

Let the cross section of the pipe be divided into five equal annular areas, A_1, A_2, A_3, A_4 and A_5.

Let the velocity heads at the centers of these annular areas be h_1, h_2, h_3, h_4 and h_5.

Let the velocities at the centers of these annular areas be V_1, V_2, V_3, V_4 and V_5.

$V_1 = K\sqrt{h_1}$; $V_2 = K\sqrt{h_2}$; etc.

$$\text{total discharge} = A_1V_1 + A_2V_2 + A_3V_3 + A_4V_4 + A_5V_5$$

or

$$\text{total discharge} = 5A_1 \left\{ \frac{V_1 + V_2 + V_3 + V_4 + V_5}{5} \right\}$$

or

$$\text{total discharge} = (\text{total area})\ (K)$$

$$(\text{total area})\ (K) \left\{ \frac{\sqrt{h_1} + \sqrt{h_2} + \sqrt{h_3} + \sqrt{h_4} + \sqrt{h_5}}{5} \right\}$$

A large number of trials from actual tests showed that averaging the velocity heads themselves instead of the square roots gave results from ½ per cent to 1½ per cent too high, the error increasing with the variation between the highest and lowest readings observed.

Professor Gebhardt's remarks concerning the pitot tube having a beveled tube to obtain the static pressure should certainly be taken into consideration in determining the merits of that type of tube.

Professor Thomas has pointed out a result of these tests which the author neglected to emphasize, namely, that for all engineering purposes, the static pressure is constant across the cross-section of the pipe.

Several suggestions have been made as to further experiments with pitot tubes for the measurement of gases which may be summarized as follows:

a Tests with low pressures and high velocities. (Such tests are now being conducted at the University of Wisconsin.)

b Tests at high pressures and both high and low velocities.

c Tests to determine the existence of critical velocities.

d Traverses at pipe opening.

e Tests using various sizes and shapes of pipes.

f Experiments to determine a practical substitute for a piezometer, as the piezometer used by the author would be difficult to apply in many cases.

g Experiments using other forms of the pitot tube, such as the Prandtl tube mentioned by Mr. Crissey.

In conclusion the author wishes to second heartily Professor Christie's motion that, just as soon as engineers feel that there is sufficient data at hand, a standard pitot tube for fan tests should be specified and standard procedure and rules for fan tests adopted by the Society.

MACHINE SHOP SESSION

PAPERS CONTRIBUTED AT THE ANNUAL MEETING BY THE SUB-COMMITTEE ON MACHINE SHOP PRACTICE

GEARS FOR MACHINE-TOOL DRIVES

By John Parker, Providence, R. I.

Member of the Society

ABSTRACT OF PAPER[1]

There are well established gear conditions common to the majority of machine tools which, if noted, may prove somewhat of a guide in selecting the proper material for gears. These may be classified as follows:

a Gears always in mesh; material to be cast iron, machinery steel or machinery steel case-hardened, according to speeds and duty.

b Gears in sets that are removable and interchangeable, such as change gears for thread cutting, indexing, feed or speed changes, etc.; material, cast iron.

c Gears in sets that are non-removable and partially interchangeable, used as quick-change feed gears with changes made when in motion; or as quick-change speed gears with changes made when at rest but subjected to high speeds and heavy duty. Material, machinery steel case-hardened.

d Gears in use part of the time only and engaged or disengaged when the machine is stopped. Material, hard, close-grained cast iron.

The Objections to Cast Iron. The objections to cast iron for gears cover both wear and breakage. If the speed is excessive, say above 500 ft. per minute, they are likely to wear quite rapidly; and on slow speeds and heavy pressure breakage will occur, unless they can be made of adequate size, as in the case of back gears so located in the machine that it is possible to employ large diameters, coarse pitches, and wide faces.

The Safe Tooth Pressure for Cast-Iron Gears. The question of tooth pressures in cast-iron gears is somewhat problematical. The Brown & Sharpe Manufacturing Company have in successful operation a gear in the spindle drive of their largest milling machine made from a hard, close-grained cast iron having a tensile strength of 23,000 lb. per sq. in., which when running at the slowest speed sustains a pressure on the teeth of 8250 lb. It is calculated that two teeth are always in contact, which gives 4125 lb. pressure per tooth. The area in cross-section of each tooth is $1\frac{1}{4}$ sq. in., equaling 3300 lb. per sq. in.; when the gear runs at the fastest speed the pressure is about 1000 lb. per sq. in. It is not known whether the pressure could be increased to any considerable extent, but it has been overloaded to at least 30 per cent without injuring it; this was when testing out the machine and the overload was of short duration. It might be said that this gear is not subjected to any sudden shock; if it were, the allowable tooth pressure would be considerably less.

The Grades of Steel that have given Best Results and how They have been treated. For gears that are of small proportions and yet are subjected to heavy duty, it has been found that in cases where the more common steels have failed, excellent results have been obtained from using a 5 per cent nickel steel. This steel casehardens with a very hard surface and still has a strong and tough core, making it an ideal steel to use where the pressure is heavy or the gear is subjected to shock. Experience shows that drop forgings are more uniform in texture than bar stock. This grade of steel is given an oil treatment and is also annealed before machining; the oil treatment is as follows: heat to 1550 deg. fahr. and quench in oil. To anneal, reheat to 1350 deg. fahr. and cool very slowly. It is then ready to machine.

After machining, it is carbonized as follows: pack in any good carbonizing material and cover very carefully to exclude air, place in furnace and heat to 1700 deg. fahr., and hold long enough to get the desired depth of casing. Care should be taken to have it heated entirely through. Ordinarily three to four hours will suffice for this process. Then take out of furnace and cool off in the boxes; remove from the boxes and place in furnace or bath; reheat to 1550 deg. fahr. and quench in oil. Again reheat to about 1380 deg. fahr. and quench in oil or water according to the size and shape of gear. If the gear is of generous dimensions and free from sharp corners, water is preferably used. Small slender gears are quenched in oil, on account of the liability of cracking if water is used. For ordinary gears the scleroscope test should show 80 to 85 points of hardness. If the gears are used as clash gears they should be drawn to 475 deg. fahr., or about 70 to 75 points of hardness, by scleroscope test, to avoid chipping.

Degree of Hardness Advisable for Steel Gears before Machining Them. The various kinds of steels used for gears are of such a nature that they do not call for treating before machining, but where extra toughness in shafts is required to withstand torsion and bending

[1] Published in complete form in the November 1913 issue of The Journal of The American Society of Mechanical Engineers, and presented at the Annual Meeting, December 1913. Pamphlet copies may be obtained: price, 5 cents to members and 10 cents to non-members.

strains, 3½ per cent nickel steel is very satisfactory. This grade of steel is rough machined, then heat treated, as follows: place in open furnace or bath, heat to 1500 deg. fahr., and quench in oil. It is advisable to experiment with a small quantity in each batch before subjecting a whole lot to the drawing out heat, which should commence at about 700 deg. fahr. If the scleroscope registers between 50 and 58, the correct hardness has been obtained; if higher than 58, the parts should be reheated to a higher temperature than before; if lower than 50, the parts should be rehardened. After this treatment, the pieces are finish machined. No further hardening is necessary. When machining, slow speeds and feeds must be used.

Hardening after Machining, and the Scleroscope Test. Practically all alloy steels and all low-carbon steels are hardened after machining and finished by grinding after hardening. About 0.010 in. on the diameter is left for this operation. All gears should run true, and to obtain this result not only are the holes ground true with the pitch circle, but the hubs are ground on their faces so they will set square with their shafts when tightened up by nuts. The scleroscope test for 30 to 35 point carbon machinery steel is anywhere from 80 to 90, and for 5 per cent nickel steel for ordinary gears 80 to 85, and for clash gears 70 to 75. All steels are tested by the file in addition to the scleroscope. The file test by an expert is very reliable and some feel that possibly more confidence can be placed on his judgment than on any testing instrument.

The above notes apply to spur and bevel gears. For worm and worm-wheel drives, the worm should be made of machinery steel, casehardened, and the wheel of a hard bronze. Both should run in a bath of oil, especially if under high speed and heavy duty. Spiral gears should be used only where the duty is light. The material should be the same as for a worm and wheel, and they should also run in oil to avoid cutting.

For index mechanisms, where accuracy is essential, if the worm is hardened the thread must be ground afterwards. This is done in all the spiral heads of Brown & Sharpe's make. Generally, the worm, made of tool steel, is left soft. Worm wheels used for indexing purposes only are usually made of cast iron, and invariably if of large diameter. High-multiple threaded worms for indexing mechanisms should not be used; a double thread can be tolerated, but not more, if accurate indexings are required.

DISCUSSION

John Riddell referred to the necessity for correct design in gears and to the attention which they should receive in the process of manufacture in pattern shop, foundry and machine shop.

If the foundry is large so that it can set apart a cupola or a melt in a certain cupola, the results may be all that can be expected from cast gears, but if the foundry is of medium size and makes no particular melt for gears, common cast iron that may be very soft and porous is the result. Cast iron for machine tools and other apparatus generally will vary somewhat with the foundry and even the section of country in which such castings are made.

The writer believes that he was among the first in the United States to use the hobbing process for cutting gears. As originally started there were some drawbacks with the process and there is still something to learn.

Various attempts have been made to improve the indexing device, some of which appear to be very good, but others of which, while eliminating one error, have introduced several other irregularities, and do not seem to have made the general improvement expected by the designer.

As to the other materials outside of cast iron and gun iron, great improvements have been made, due to the automobile and high-speed requirements, such as in turbine engines and the connection of electric motors with machine tools. The latter has been made by the use of cloth pinions.

These pinions seem to have a number of advantages over other types of non-metallic pinions and have proved in a wide variety of applications to have strength about equal to that of cast iron. The Lewis cast-iron formula is used in their design and many users believe that by virtue of their elasticity they withstand service shocks better than cast-iron pinions of the same dimensions. Their life in most applications appears to be a little longer, and their substitution for cast iron on a very large scale is, therefore, only a question of whether their higher cost is justified by their more quiet operation.

The gear may be made of machinery steel or a casting, but the pinion is usually of harder material and very frequently oil tempered, unless cloth or rawhide is used.

Gear boxes should be used in some places but not in others. Sometimes when in a hurry for machine tools, gear boxes are ordered for the initial drive, where ordinarily the writer would prefer to use a variable-speed motor to take the place of unnecessary gear boxes. No matter how well these gears are made they are bound to make too much noise. A gear box for changing feeds and for automobiles, perhaps is necessary at present.

Much is yet to be done in designing machine tools as to gears for driving the machine as well as for giving different feed variations. On feeds of large machine tools, such as planers, and large planer type milling machines, electric motors are being very successfully used, which not only cut out a lot of gears but other mechanisms, and are a step in the right direction. Gears, especially bevel gears, have always seemed a necessary evil, though many attempts have been made to use spiral and helical gears to eliminate some of the difficulties inherent in bevel gears.

The writer would like to urge upon the trade, a more accurate system both of indexing and of mounting gears after they have been properly indexed and cut. If a gear is allowed to have the slightest play on a shaft it will run eccentrically and no matter how little this eccentricity may be there will be a noise which cannot possibly be eliminated.

F. V. McMullin (written). Having had experience in furnishing forgings to gear makers, I can say that today, their specifications are based mostly on chemical composition of the steel, some on physical tests, while a very few give both chemical and physical. For the ordinary gear that

is neither case-hardened nor heat treated, gear makers usually call for 25 to 30 point carbon, no other element being mentioned. If the gear is to have hard usage, they will call for a higher carbon, 40 to 50 point, or even 60 point being demanded; some also specify the manganese, sulphur and phosphorus.

Gears that are to be case-hardened should be made of steel of not more than 20 point carbon, as this more easily takes the case. Some makers still buy 30 point carbon steel for case-hardening, which in my opinion is unwise. When gears are to be oil tempered a 40 to 50 point carbon steel or a 3½ per cent nickel 40 point carbon steel should give satisfaction. A 3½ per cent nickel, 25 point carbon steel is used both with and without heat treating, though I think the latter is not good practice, as such steels should always be treated. Where a gear is to have hard wear and the design permits the use of a thick tooth, high manganese steel will be found satisfactory. One well-known machine tool builder uses a high manganese gear in mesh with a train of heat-treated nickel chrome gears with very good results.

I append a few typical gear specifications from our order files:

a Carbon 20 to 30 point; Phosphorus and sulphur less than 0.04.

b Carbon 0.07 to 0.10; Manganese 0.30 to 0.40; Sulphur 0.035; Phosphorus 0.01, and Silicon 0.01.

c Carbon 0.40 to 0.50; Manganese 0.50 to 0.55; Phosphorus 0.01 to 0.015, and Sulphur 0.035 to 0.04.

d Carbon Steel Annnealed: Ultimate tensile strength 80,000 lb.; elastic limit 40,000 lb.; elongation 22 per cent in 2 in.; contraction of area 35 per cent.

e Nickel Steel, or Nickel Chrome, or Carbon Steel: Phosphorus and sulphur less than 0.04; ultimate tensile strength 80,000 lb.; elastic limit 50,000 lb.; elongation 25 per cent in 2 in.

f Carbon Steel, 55 to 65 Point Carbon: Ultimate tensile strength 85,000 to 100,000 lb.; elastic limit 45 per cent of ultimate; elongation 22 per cent in 2 in.; contraction of area 35 per cent.

A. L. De Leeuw (written). In regard to the use of hardened clash gears, we replaced all soft gears by hardened ones, in our milling machines, not because the soft gears were not satisfactory, but because it was impossible to control the operators handling the milling machines. If the operator would follow the injunction not to throw in the gears when the machine was running, soft gears would have been entirely satisfactory.

One of the speakers said that in general the trade demanded steel gears. This is a clear case of the minority ruling. In 99 out of 100 cases, cast iron is good enough; but in the hundredth case there is trouble; this trouble is noised about, and then the conditions of competition make it absolutely necessary to change over to steel, even though cast-iron gears might have a number of advantages of their own.

In regard to the use of cast-iron gears for slow drives, it has been the experience of a good many engineers, and, to a certain extent, has been my own experience, that the Lewis formula is too conservative for low speeds. Pressures may be used, 50 per cent and, in some cases even 100 per cent, above the figures of the Lewis formula.

I want to call attention to the table Mr. Parker gives, in which he speaks of gears in sets that are non-removable. He mentions that each one of these gears is used at times, thus distributing the wear over a number of gears. This idea may be in the mind of the designer, but whether all of these gears are actually going to be used is a matter over which there is no control after the machine enters the shop of the customer. It may be that a single set of gears will be used all the time.

H. F. L. Orcutt said that in Great Britain the gear box drive is coming in, copying the American practice, and it is recognized that the gear box drive and the single pulley drive are the developments of the future.

The requirements of the London police on the English buses may be interesting. The makers have had to use chain drives in the transmission box to satisfy the demands of the police for quiet transmission. He thought those who had been in London and witnessed the running of the buses could never have heard more quiet transmission.

A. W. Thompson said that he was primarily interested in the manufacture of gears for textile machines and spoke of the satisfaction he had found in the hobbing process for cutting spur gears both as regards economy of manufacture and smoothness of running. In textile work the use of gears with teeth cut at an angle is favored for special purposes where it is desirable to eliminate vibration, for which the hobbing process is particularly well adapted.

E. H. Neff, in reference to the mention that had been made of the demand of the trade for steel gears, said that the user demands a tool which can be used continuously. Inasmuch as steel is stronger than cast iron it will bear more abuse than cast iron and the manufacturer of machine tools is inevitably pushed towards equipping machines with steel gears. The elimination of cast-iron gears, however, will be a matter of many years rather than as a result of any sudden change.

F. Der. Furman (written). There seems to me to be a pretty close link between item A and the different materials that are there given in the third column of Table 1. The author uses the words, "Gears always in mesh, the wear on the teeth being constant." I doubt whether this is a proper expression, because the wear on the teeth, as I see it, is greater at the tips, there being more sliding as the line of contact passes away from the line of centers; and if there is more sliding at the ends of the teeth, naturally there should be more rapid wear at that place. And then, as there is more wear, it leaves the bulk of the work to be done by the teeth on or near the pitch line. Now, if we have a material that is soft enough to wear away fast, under that rubbing action, the pressure between the teeth will take place near the centers of the teeth and the work of transmission will be better done. And if the tooth is made of a hard material which refuses to wear away or to yield readily as the rubbing action takes place at the ends of the teeth, that hard tooth is going to receive more punishment at the ends and more stress in the teeth will be set up than in the tooth made of softer or more yielding material. The center of pressure which produces the greatest stresses in the teeth, travels from the tip of the tooth to the center and back again alternating until the teeth are worn out or until they break, but in the soft or yielding material the most injurious pressure

which is at the tip of the tooth will last for the shortest period of time. Of course, on the other hand, the tooth that is made of hard material is stronger to receive the punishment, but I think in considering the materials that are used, we can get along better if we also consider the action which occurs between the teeth.

C. R. Gabriel mentioned a case of high-speed gearing in connection with automobile torpedo engine construction showing the possibilities of gear drives at high speed and heavy duty. In the torpedo an engine of the turbine type is used to drive the propeller shafts through a balanced train of eight gears, made of chrome nickel steel, case-hardened, the teeth of the spur gears being ground after hardening. These gears work under very heavy duty, considering the proportions of the gears.

The engine develops 125 h.p., but due to the fact that the turbine motors, which run in opposite directions, do not develop equal amounts of power, one set of gears is required to transmit 75 h.p. The spur gears consist of pinions with 24 teeth and gears of 80 teeth, 10 pitch and 1 1/8 in. face, making a ratio of 3 1/3; the bevel gears have a ratio of three to one, the pinions being 1½ in. pitch diameter and the mating gears 4½ in., also 10 pitch. The speed of these gears is very high, that of the spur gears being 7500 ft. per min., and of the bevels 1400 ft. per min., the tooth pressure on the bevels being about 1800 lb.

This construction has been well tried out, several hundred torpedos being fitted with engines of this type. While the length of service is not such as gears in machine tools and automobiles are required to stand, some of these torpedos have made several hundred runs of 8 min. to 10 min. duration, and gears examined after this amount of service showed no appreciable wear. It should be mentioned that these gears are never subjected to shock, as the engine starts with an accelerated motion, and the load is practically constant throughout the run. In operation these engines are very noisy, but in torpedos this is not an objection, as when submerged in the water the noise is not heard.

The Author. In regard to the remark of Mr. Riddell, that he did not like the variable speed mechanism in his machines on account of the noise and the use of gears in general, I believe the spindle speed gear box to be one of the best things we ever put in milling machines. We find that we can do about four times the work in the milling machines by the constant speed belt drive and variable speed mechanism, than with the old cone pully belt drive. As to the noise, we have no trouble in the milling machines made by the Brown & Sharpe Manufacturing Company; the hardened gears run very nicely and quietly.

Regarding Professor Furman's criticism of the gear conditions specified in class A, what I meant as to the wear of the teeth being constant was that the teeth are always engaged, and there is no moving from one gear to another, such as the gears in the milling machine knee, where they are always in action when work is being done.

Mr. De Leeuw's statement that the hundredth case might be using only one speed is very true; but I have treated this subject in a general way. Of course, we have different conditions to meet and the machines are designed for the general run of the trade.

CAST IRON FOR MACHINE-TOOL PARTS

By Henry M. Wood, Cincinnati, Ohio

Associate Member of the Society

ABSTRACT OF PAPER[1]

In the belief that valuable information could be secured by a comparison of the present practices of representative machine-tool manufacturers, the writer asked a number of machine-tool makers in different lines and in different sections of the country if they would be willing to submit an outline of their practice. The following excerpts pertaining to the mixtures used and chemical analyses of the castings are quoted from their replies:

A Builder of Special Machine Tools: Our iron is bought on analysis specifications, covering two grades as follows:

Two Plain	
Silicon	1.75 to 2.25
Manganese	0.60 to 0.90
Phosphorus	0.50 to 0.80
Sulphur	0.50 and under
No. 3	
Silicon	1.00 to 1.50
Manganese	0.50 and over
Phosphorus	0.50 to 0.80
Sulphur	0.07 and under

In addition to the above we use materials as follows: No. 1 machinery scrap, mild steel scrap, manganese steel scrap. The last carries 12 per cent of manganese with quantities of the other elements so small that they are negligible in gray iron foundry work.

Our mixtures are figured out on the actual analysis of each bar, insuring in the castings uniformity of analysis and consequently of physical characteristics, such as strength, density, and machining qualities. In general practice we use three different mixtures suited to our varying needs.

In our first mixture we include our lighter castings such as pulleys, small gears, washers, hand-wheels, brackets, and the like. In this mixture we endeavor to have the following analysis:

Silicon	1.90
Manganese	0.60
Phosphorus	0.70
Sulphur	0.08

This is usually secured by the use of a mixture of 50 per cent of two or three lots of two plain iron and 50 per cent of scrap. The proportions of the different pig irons are adjusted to produce the proper analysis in the mixture, and the scrap is partly our own foundry return and the balance No. 1 machinery scrap.

Our second mixture covers all our heavy work, such as planer beds, posts, tables, face plates, frames, etc. These castings require strength and sufficient density to permit the

[1] Published in complete form in the November 1913 issue of The Journal of The American Society of Mechanical Engineers, and presented at the Annual Meeting, December 1913. Pamphlet copies may be obtained: price, 5 cents to members and 10 cents to non-members.

machined surface to take a high polish. These ends we accomplish by an analysis as follows:

Silicon	1.40
Manganese	0.60
Phosphorus	0.60
Sulphur	0.09

This mixture consists of 45 per cent of two or more No. 3 irons and 55 per cent total scrap, shop and No. 1 machinery together. Should this mixture fail to yield sufficient manganese the addition of 1 to 2 per cent of manganese steel scrap is made to correct it.

The third mixture is semi-steel, used principally for large blank gears and castings requiring special strength. Its analysis is

Silicon	1.20
Manganese	0.90
Phosphorus	0.45
Sulphur	0.09

Its average makeup is

	Per Cent
Machinery scrap	30
Mild steel scrap	20
Manganese steel scrap	5
No. 3 pig iron	45

The above mixtures cover our entire range of work except cases where some special composition is required or desired.

A Manufacturer of Precision Machinery: In our work we run various grades of iron to meet the conditions existing in the machines or in the parts of machines under consideration.

In a general way our mixtures, in per cent, run as follows:

Silicon	Manganese	Phosphorus
3.00	0.60	0.80
2.40	0.65	0.70
2.00	0.65	0.60

The first is for the average run of castings of smaller size; the second for the larger castings. Where we need a special close-grain iron we use the third mixture.

A Manufacturer of Milling Machines: We have never carried on any extensive experiments to learn the best mixtures of cast iron for our purposes. We use in the tables, knees, saddles and vises about 20 per cent of steel with a view to obtaining a close-grain casting, and increasing somewhat its strength.

We use practically no cast iron for gears or small parts, these being made of steel drop forged in the case of larger parts, and also in the case of smaller parts when not adopted for manufacture from the bar.

The ideal casting is, of course, one that is so close as not to show any grain when finished and at the same time, just as hard as it can be, and be worked into shape.

The question of strength is probably not so important, as there is opportunity to use sufficient bulk to obtain strength. At any rate this is true of the parts that we make of cast iron, for, as stated above, all our gears and like parts are made from steel which is casehardened.

A Manufacturer of Heavy Lathes: With the heavier castings we are using a semi-steel mixture with about 20 per cent of steel. The analysis of this iron shows 1.60 to 1.70 silicon, 0.65 to 0.75 manganese, 0.40 phosphorus, 0.8 to 0.10 sulphur. While our carbons are not noted as a rule, we get a check on these every once in a while, showing the total carbons about 3.50 to 3.60.

Our iron for smaller pieces runs from 1.80 to 1.90 in silicon, 0.40 to 0.50 in phosphorus, 0.65 to 0.70 manganese, 0.07 to 0.10 in sulphur. The total carbon shows up practically the same in both mixtures. Our test bars on the first mixture break at from 2800 to 3200 and on the latter mixtures at about 2600. This refers to 1 in. by 1 in. standard bars supported on 12 in. centers.

A Manufacturer of Grinding Machines: We use castings with various proportions of steel according to the size of the casting and the place where it is to be used, so that today we have very bright lustrous surfaces and it is possible to get accurate alignment.

PRACTICE WITH REFERENCE TO CHILLING CASTINGS

There is a wide difference of opinion among machine-tool manufacturers as to the desirability of chilling any surfaces of castings. In view of these differences and the idea held by some that it is impossible to chill an iron of high tensile strength without making it so hard it cannot be machined, the practice of the Lodge & Shipley Machine Tool Company, with which the writer is connected, is here outlined. Three average analyses are as follows:

Silicon	Sulphur	Phosphorus	Manganese	Tensile Strength
2.16	0.065	1.01	0.40	22,310
2.17	0.065	1.01	0.39	24,840
2.45	0.076	0.63	0.71	24,195

The first analysis is of a specimen taken in January 1913 from the first iron run in a heat; the second, from the last iron of the same heat; the third, from the average iron of a heat in September 1913.

This same iron is used for lathe beds of which the ways are chilled, also for other cast-iron parts which do not require the high tensile strength of semi-steel. For some parts, such as compound rest top slides and reverse plates, we use semi-steel. Parts subject to greater stress or to severe shock are made of steel.

The Effect of the Chill on a casting is well shown in Fig. 1. This shows the cross-sectional fracture through the finished ways and a portion of the side wall of the chilled bed for a 30-in. lathe. The reproduction clearly shows that the iron even far away from the chill in the side wall of the casting is dense and of as close grain as other good cast iron; it also shows the much closer grain of the iron below the finished surface as a result of the chill in closing up the iron and making it harder and more durable. In the 30-in. bed, as plainly shown by this specimen, the close iron produced by the chill extends to a depth of 1½ in. to 2 in. below the finished surface of the ways, thus proving that the chilled iron is not all removed in the planing.

Degree of Hardness. Scleroscope test on chilled beds finish planed but not scraped gave as a result of eight different tests on four different beds, scleroscope readings of 40 to 42 with an average of 41. Similar

tests on chilled beds which had been planed and then scraped gave a practically constant scleroscope reading of 42. Comparative scleroscope tests on a heavy section of unchilled cast iron which would give as nearly as possible conditions parallel to those just quoted gave readings ranging from 18 to 22, with an average of 20. These tests indicate that the chilled ways are much harder than the unchilled.

Action of the Chill. The chilled surface is produced by a series of cast-iron chill plates each about 6 in. long placed end to end in the mold. The use of separate short plates eliminates much of the warping and twisting which would occur in a long chill plate.

If a thick chill plate is used with a low-silicon iron the surface of the casting is chilled so hard that it cannot be machined. The desired result is attained by regulating the thickness of the chill plate to suit the size of the casting for which it is used; then a low-silicon iron of high tensile strength can be successfully poured. The heavier the casting, the thicker the chill plate.

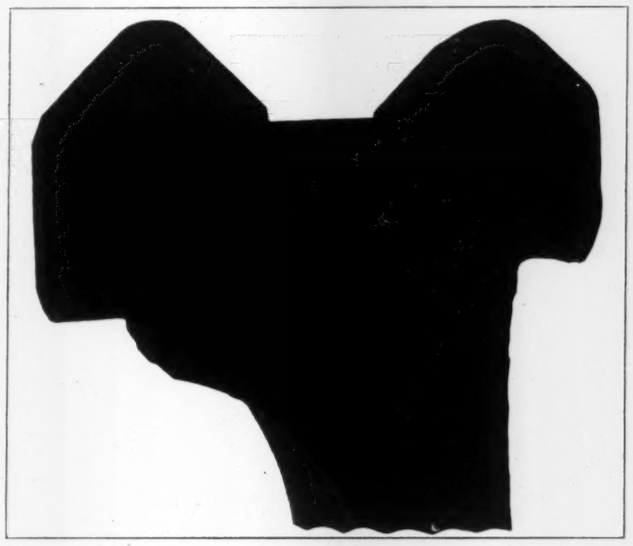


FIG. 1 CROSS-SECTIONAL FRACTURE OF CHILLED LATHE BED

The action in the mold is that when the molten iron strikes the cold plate it is chilled and hardened; then the heat in the mass of iron forming the body of the bed casting gradually warms the chilled surface and the chill plate, thus annealing the casting or "drawing the chill," just as when in tempering a chisel the heat in the shank of the chisel "draws the temper" of the cutting edge to the proper point after the cutting edge has been hardened by quenching in water. This annealing of the chilled surface of the casting produces the desired form of hard, close-grained gray iron.

The thickness of the chill plate used is such that the heat in the casting will anneal the surface sufficiently to permit planing, although at a greatly reduced cutting speed, and yet retain the benefits of the chill.

The advantages of chilled wearing surfaces for machine tools are:

a Much harder surfaces, which experience has proved are vastly more durable than similar unchilled surfaces.

b A hard guiding surface with a relatively soft carriage, bringing the bulk of the wear on the carriage and thus maintaining the alignment of the guide.

c A denser and much more closely grained surface of the casting, giving better appearance.

d An exceptionally smooth finished surface, in which there are no pores where dirt and grit may become imbedded to cause rapid abrasion of the other bearing surface.

Chilled surfaces are more advantageous on some machines and some parts than on others. In the case of a lathe the carriage will often be used for long periods of time on chuck work or on short jobs between centers which brings all of the wear on a comparatively short length of the bed just in front of the headstock; such uneven wear on the unchilled bed destroys the accuracy of the alignment for long work. Chilling the ways brings the wear principally upon the carriage, and even if the carriage is worn, the alignment at all points along the bed will remain relatively true.

Our experience, based on the use of chilled ways on beds of all sizes of our lathes for more than two years, is that no internal stresses are created by the chilling; that the surface is not made more susceptible to a peening action; that the surface can be equally as well lubricated as before; that iron of high tensile strength is used; and that the increased hardness and closeness of grain of the chilled surface vastly increases the durability and permanency of alignment. We find no disadvantage except a somewhat increased cost.

DISCUSSION

W. WALLACE MCKAIG[1] called attention to the mixture for heavy lathe of semi-steel, the analysis of which is Si, 1.60, Mn, 0.65 to 0.75, P, 0.40, S, 0.8 to 0.10, given in the paper, and said that there seemed to be a very wide latitude in the sulphur. Furthermore, an iron with sulphur in the proportion of 0.8 would be white hard all the way through and would be impossible to machine. An iron of the above analysis with sulphur as low as 0.3 would also be white hard. He would appreciate information as to a way of making a 20 per cent semi-steel with sulphur in the proportion of 0.8, in which the castings are soft enough to machine.

A. LEWIS JENKINS wrote that most machine tools are required to resist deflections and vibrations, and when sufficiently rigid and massive to satisfy these requirements there is practically no danger of breakage. About the only ma-

[1] With Merwin McKaig, Cumberland, Md.

chine tools designed for strength in which the deflection may be neglected are shears, punches, presses and hammers.

Beds and carriages of lathes; housings, cross-rails, tables and beds of boring mills; columns, and knees of milling machines and shapers; columns, arms and tables of drilling machines, are examples of machine parts requiring stiffness; they never break. The very lowest grades of iron would be entirely satisfactory for these parts from the standpoint of strength, provided the parts were sufficiently heavy to resist the vibrations and deflections caused by the pressure of the tool.

The ultimate tensile or the transverse strength of a test bar is of no greater value in proportioning some parts of machine tools than the specific gravity of the material.

The most important physical property that may be determined by a test is the deflection under a load equal to about 1/10 of that required to break the bar, or about 250 lb. at the middle of a 1 in. by 1 in. bar on supports 12 in. apart. It would be better to use a bar that is at least 24 in. between supports in order to get accurate deflection readings.

Hodgkinson's Experimental Researches (1860) gives the ultimate breaking load and the modulus of elasticity at a load of 112 lb. for about 250 bars 1 in. by 1 in. by 54 in. between supports. Plotting the breaking load against this modulus of elasticity (at 9072 lb. per sq. in. transverse stress) showed no definite relation between the ultimate transverse strength and the elastic properties. It is also evident that no relation exists between the deflections at 112 lb. and at rupture.

In view of these results neither the ultimate strength nor the ultimate deflection of a test bar is of any value in determining the most essential property of the material.

The values of the moduli of elasticity in Hodgkinson's results vary from 11,539,333 to 22,733,400, which means that if a casting were made from each of these materials one might have a deflection twice as great as the other. The variations in the elastic properties of the iron may cause an appreciable effect on the accuracy of some machine tools.

Complicated castings should preferably be made from metal having a small shrinkage, thereby decreasing the initial stress due to cooling, warping, shrinkage cavities and some of the visible defects commonly seen on finished surfaces.

It is not an easy matter for some foundries to get a mixture that will produce desirable machining properties and have a grain sufficiently close to take a high finish. Good results in this respect have been accomplished by the use of charcoal, certain grades of coke, steel scrap and ferro-alloys.

In the selection of castings the machine tool builder should consider, together with the machining and finishing properties, that property of the iron which resists deflection and upon which depends the stiffness and corresponding accuracy. The ultimate strength is a minor consideration.

Thomas D. West referred to the difficulty experienced by one manufacturer who had replied to the inquiries sent out by the author that he had had trouble from the scratching of chilled ways used on machine tools through some little particle of metal which had settled on them.[1] Mr. West suggested that the chilled surfaces might have been wavy or streaked so as not to present a smooth homogeneous surface; and that the trouble might be due to the failure to use a varnish to coat the chillers with.

All chillers generally require to be coated with wet blacking which must be dried; oils, chalk or other coverings that do not require any heat drying are also used. For the purpose of lathe ways and chiller plates or blocks the following recipe is the best the writer knows of and has not to his knowledge been heretofore published. It is what some of our leading carwheel makers use to obtain the perfect surface seen on the threads of their wheels which wear smooth without causing any scratches.

Suitable proportions for this varnish are shellac, 34 lb., lamp black, 4 lb., wood alcohol, 9 gal.; or if a smaller quantity is desired the mixture in the same proportions. The alcohol is put into a barrel with the shellac to cut it up well, so that it will be entirely liquid before putting in the lamp black. This alcohol costs 50 cents per gal. and is 95 per cent alcohol. Recent experimenting has led to the use of mineral blacking or dust, obtained from foundry companies, in preference to the lamp black, as it gives a smoother skin to the chilled face, does not gum the chillers as the lamp black does, and only about half as much is required.

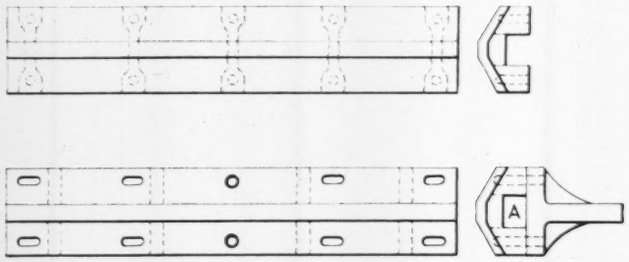


Fig. 2 Chiller for Latheways

Should the face of the chillers show signs of any roughness or scale other than that caused by the varnish, some dry sand is rubbed over it with waste, or emery or sand paper may be used. The varnish is applied with a brush, and the chillers are given one coat and then allowed to dry in the open for twenty to thirty minutes. On top of this coat of varnish a thin coating is applied, composed of half kerosene oil and half common black oil, and on top of this again a little mineral blacking is dusted on to prevent the oil and kerosene mixture from forming streaks and to keep it in a smooth body. The dusting is done by shaking it through a hand bag, such as is used by stove molders and general foundrymen for shaking general dry blackings on their molds. This last coat requires only about 15 minutes to dry, after which the mold having the chillers can be poured.

The author mentions the use of a series of cast-iron chiller plates, placed end to end in the mold to eliminate the warping and twisting which is liable to occur in a long chiller plate. Mr. West, however, believed that foundrymen would prefer to use one continuous chiller piece, provided its warping could be prevented, and suggested that where long chillers are desirable, they be made no thicker than necessary to give the required depth of chill, and that means be arranged for bolting a chiller plate to a rigid casting or beam of sufficient stiffness and strength to keep the chiller plate from

[1] See complete paper for reference—Editor

warping. Fig. 2 indicates such a construction. The upper view shows the chiller plate and the lower view a T-shaped beam with the plate bolted to it. The elongated bolt holes in the beam allow for expansion. The bottom of the lugs of the chiller plate and the face of the beam should be planed to unusual straightness and the chiller casting can be made either of steel or wrought iron, since there is practically no difference in the chilling qualities of these two metals, as indicated by the writer's experiments.[1] An air space should be allowed at *A* (Fig. 2) which may be left open or filled with rammed sand or other material of low heat absorbing quality; or water or air pipes may be inserted in this space to retard a "drawing of the chill" and to eliminate the possibility of the beam becoming heated to such an extent as to cause its warping.

FORREST R. JONES sent the following excerpt from his note book as of value in relation to the durability of flat rubbing surfaces of cast iron. The stationary member is referred to as the "guide," and the moving member as the "block."

Alfred Herbert, Ltd., Coventry, England. Visited September 5, 1902.

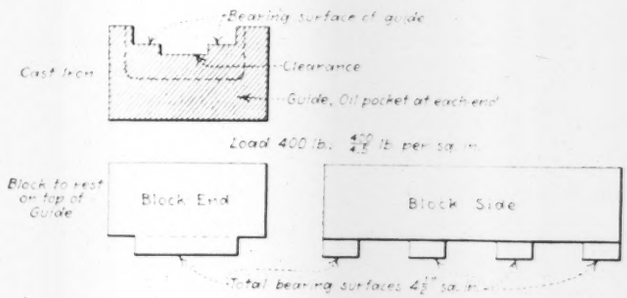


FIG. 3 [BLOCK AND GUIDE FOR TESTING RUBBING SURFACES

Experiments had been made on flat rubbing surfaces of various kinds of cast iron. Both surfaces always of the same iron. The bearing surface of the guide a narrow strip along each side; block held in place by the upper lips of the guide. Middle of guide cut away for clearance. Oil pocket at each end of guide. Block has narrow strips across its length; ends of cross-strips rest on the bearing strips of the block.

No oil-grooves or indentations (other than the pores of the metal) in the bearing surfaces. Enough oil used to act as a bath.

Each block was run (slipped) back and forth 84 miles on its own particular guide. Hardness was tested by drilling.

Softest metal by drill test showed best wearing qualities. The softer metals were the more porous.

After 84 miles of slipping the softer metals showed practically no wear; the scraper marks still remained on both block and guide. The oil remained clear. Harder blocks showed considerable wear. With them the oil soon became black, almost as black as ink.

Total bearing surface of block, 4½ sq. in.; total load, 400 lb., bearing pressure $= \frac{400}{4.5} =$ 89 lb. per sq. in. nearly.

At a date some eight or ten years earlier than that of this memorandum the Aermotor Company of Chicago found that a thoroughly chilled cast-iron bearing would far outlast any other of numerous materials used for the bearings of the horizontal shaft of the vane wheel of their windmills. These bearings were generally neglected as to oiling, and before the chilled cast iron was adopted, gave trouble by rather rapid wearing out when thus neglected. The cast iron used for the aermotor bearings was chilled hard and white, like a car wheel, a roll for a steel mill or a flour mill, or the mold-board and point of an agricultural plow. The shaft was of ordinary machine steel.

A few years ago, the writer had occasion to test the durability of chilled cast iron as a bearing surface when rubbing against tempered spring steel as the mating bearing surface. The coiled spring gripped the entire circumference of the round cast-iron member. The cast iron used was chilled hard and white. After the surfaces had slipped over each other more than 40 miles actually measured, and probably half as much more not measured, under all conditions of lubrication and the lack of it, at a bearing pressure more than 300 lb. per sq. in., the chilled iron still showed the marks of the fine-grained emery wheel that had been used to grind its friction surface.

E. H. MUMFORD (written). Speaking of this question wholly from the foundry standpoint, it occurs to me that too much stress is commonly laid on the strength detail of cast iron for machine tool uses, considering the use to which it is put after it gets into service, other than in gears. In my steam pump experience I used Keep's test quite extensively, with more attention to the shrinking and chilling tendencies than to the strength tendencies; I try to use a uniform test bar so as to get absolutely relative results. It is undoubtedly true in the use of cast iron that its strong tendencies to shrink in certain dimensions in rigid castings develop stresses which lead almost to fracture before the real load comes on, so that strength is a minor consideration under the circumstances.

I do not refer to the form of shrinking which produces honeycomb spots in the center of joining parts as where pump diaphragms join the side-walls, or spokes join wheel rims and hubs, and which are known as "shrinks" or "draws" in the foundry, for that is a different matter. Castings are weakened more by cooling stresses due to shrinkage than by lack of intrinsic strength as shown by breaking tests, either transverse or tensile.

I had supposed that it was well known that such chilling as Mr. Wood refers to in his paper is entirely different from that in car-wheel or roll or cylinder castings, but the comment made by manufacturer No. 34 seems to show that there is some misconception of what chilling means in the sense in which Mr. Wood has used it in his paper. It should be clearly understood that the chilling referred to bears no relation to the chilling of car wheels or rolls made from low silicon iron.

The quick cooling of high silicon iron on running against a chill prevents the segregation of graphitic carbon in large masses and holds the iron to a closer texture without any such hardening of the surface as interferes with proper machine cutting; whereas, with low silicon iron, the surface, and for considerable depth below it, contains no graphitic carbon whatever and can be touched only by a grinding wheel or the special chilled tools used in roll turning.

[1] New Processes for Chilling and Hardening Cast Iron, Trans.Am.Soc.M.E., vol. 34, p. 235.

Bradley Stoughton. I think the Society should be congratulated upon this paper, and upon the method which was followed in writing it, whereby the opinion is obtained of several men who have had experience in these matters, and who are willing to give anonymously the benefit of their experience.

I want to call Mr. Wood's attention to the natural alloys of iron, nickel and chromium smelted from the Mayari ores of Cuba. I think Mr. Wood will find that they have been used to some extent in machine tool work.

A. L. De Leeuw (written). I want to call attention to the following statement contained in the paper: "The ideal casting is, of course, one that is so close as not to show any grain when finished, and at the same time be just as hard as it can be, and be worked into shape." I want to warn against the "of course," which seems to take it for granted that we all agree with it. I believe it is a little bit early to agree entirely with this statement. We like to have the appearance of the casting close-grained, but it is doubtful if the close-grained casting is always the most serviceable. Experiences of other people, and some of my own, have shown that the presence of graphite in the casting is of decided benefit; especially if the graphite is near the top after the scale has been removed. This may be the reason why soft blocks wear better than hard ones.

Another thing touched upon in the previous discussion is that it may be advisable to have different hardnesses in the surfaces which wear together; Mr. Wood indicated that it is well to have the lathe bed harder than the carriage. We cannot get away from the wear. The number of cases where this wear is so small as to be negligible are so rare that we may just as well make the general statement that we must provide for the natural wear of moving machine parts. I would suggest that Mr. Wood's statement be broadened out, and that we say that we should make the part which guides, harder than the part which is guided.

The point which was brought out in the discussion in the preceding paper on gears is, that in the softer cast-iron gears there is naturally a wearing at the point of the teeth, and that when this point is worn sufficiently, the wear will then come naturally on that part of the tooth where it should be. I wish to call attention here to the fact that if the gear is of such softness that the point wears away, then, after the pressure has come to the center, the center will wear away, and then the pressure will come on the point again. I really do not believe that any such kind of action takes place, but rather that there is an undue wear over the entire tooth if the material is too soft. I believe that in order to avoid the excessive wear in gears, the proportions and sizes of the bearing surfaces, and the hardness of the materials, should be as ample as we can make them.

There are certainly a great many pieces where chilled castings can be used to great advantage, and not only for wearing surfaces. This refers especially to T-slots. In most machines, practically all except the very largest, T-slots are finished out, which makes the under side of the lip of the T-slot rather soft. Chilling this T-slot will condense the material, and prevent the lip of the T-slot from swelling unduly when fixtures or pieces of work are clamped down.

D. J. Riggs wrote that the author has referred to chilled iron as that which cannot be planed, filed or scraped; and this is the common conception amongst us. But we all know that some foundry irons will hardly chill at all and that other irons may be found anywhere between these two extremes. It seems that in applying chills to lathe beds, the author has not gone to the extreme limit of hardness. In the case cited where there was trouble from the scratching of chilled ways, they have probably either used an iron that chilled too easily, or used too heavy a chill. After getting the iron too hard they have undoubtedly resorted to the use of loose emery and left some of it imbedded in the iron to make trouble later.

The Author wished to present no closure.—Editor.

A RECORD OF PRESSED FITS

By C. F. MacGill, St. Louis, Mo.

Member of the Society

ABSTRACT OF PAPER[1]

In my own experience, covering about 20 years, in charge of shops where forced fits were made, I have found that it was not necessary to increase the allowance with the diameter of the shaft, as the increased surface area of the fit added sufficient friction to bring the pressure up to the required tonnage, and that an allowance of from 0.002 in. to 0.004 in. on steel shafts pressed into steel hubs, and an allowance of from 0.003 in. to 0.005 in. on steel shafts pressed into cast-iron hubs of ordinary hardness, gave good results. I have yet to learn of one of these shafts coming loose.

There is no doubt in my mind that allowances greater than 0.006 in. on steel shafts pressed into cast-iron hubs, not only do not serve any useful purpose, but tend to set up strains that are injurious to the casting.

One large plant with which I am familiar issues an allowance table for pressed fits, the allowance gradually increasing with the shaft diameter. This is not followed in their shaft department, but instead a flat allowance of 0.003 in. is used without regard to the diameter of the shaft.

The table, published with the complete paper, covers 206 fits of diameters varying in size from 3.5 in. to 20 in., sufficient in range and number to demonstrate the correctness and value of the practice followed. The records are all of fits made on electric generators and motors and show the diameter of the shaft, the diameter of the bore, the length of the seat, the diameter of the hub, the material of which the hub is made, the allowance (the difference between the diameter of the shaft and the diameter of the bore of the hub into which the shaft is expressed), the pressure in tons required to force the shaft in, the maximum tension stress in the bore in pounds per square inch, the radial

[1] Published in complete form in the November 1913 issue of The Journal of The American Society of Mechanical Engineers, and presented at the Annual Meeting, December 1913. Pamphlet copies may be obtained: price, 5 cents to members and 10 cents to non-members.

pressure on the surface of the shaft in pounds per square inch, and the coefficient of friction.

In calculations relating to the subject the following formulae are used as developed by Prof. A. Morley and published in Engineering, August 11, 1911:

Total tension stress at bore of hub:

$$f_t = \frac{\frac{J}{D} \times E}{\left\{\left(\frac{m-1}{m} + \frac{1}{m_1} + \frac{E}{E_1}\right)\frac{R_1^2 - R_2^2}{R_1^2 + R_2^2} + \frac{E}{E_1}\right\}}$$

Normal pressure on surface of shaft:

$$P_2 = \frac{\frac{J}{D} - \frac{f_t}{E_1}}{\frac{m-1}{mE} + \frac{1}{m_1 E_1}}$$

Coefficient of friction:

$$\mu = \frac{P}{P_2}$$

The notation used is given in the original article.

DISCUSSION

JOHN E. SWEET. During the last third of a century at the works of the Straight Line Engine Company, Syracuse, N. Y., we have had experience on a kind of forced fits different from that of Mr. MacGill, and with results that will, I fancy, surprise him and others.

Our crankshafts were made by using two flywheels with very large bosses for the throws of the crank, and, in forcing the crankpins in these bosses out of the center, and in forcing in two pieces to form the shafts. These shafts and cranks were of Coffin treated steel, forced into the cast-iron bosses, and these forced fits were without keys. The size of the crankpins varied from 3⅞ to 5$\frac{13}{16}$ in., and the shafts varied from 3⅜ to 4¾ in. The allowance for the fits was after we learned the trade, about 0.0015 in. to the inch, and another thing we learned was that while the boring and turning was very carefully done there would be a little wearing away of the ridges at the parts that first entered, so that to get a rigid bearing at the shoulder, the fit of the shaft was given 0.001 in. taper.

To give some idea of the permanence of these connections, we turned out thousands of these fits, and, in cases where 4¾-in. shaft fits without keys were coupled to generator shafts, where the shafts in the armatures were 6 in. or more, and with 1½-in. keys, the fits in the wheels never slipped. Where the holes are reamed and the shafts are ground, two-thirds as much allowance is ample, and, where the shaft and boss are both steel, it is likely that one-half as much allowance will do, and that is dependent on the length of the fit whether turned and bored or reamed and ground fits.

Ought not a shaft 8 in. in diameter take a pressure four times as great to make a good force fit as one 4 in. in diameter? Will the same allowance give this? Mr. MacGill's table only shows twice as much. There is four times as much surface in the 8-in. size as in the 4-in., even though only the same length of fit.

SANFORD A. MOSS. Mr. MacGill's mathematical methods are undoubtedly correct. However, his values of force for pressing and the corresponding values of coefficients of friction seem very high. There is great variation in the individual cases of the table, but this always occurs. I have many records similar to those of Mr. MacGill's and they vary as much. These are for steel hubs on steel shafts and I have given their general average in a paper on this subject.[1] This led to a coefficient of friction of about 0.038, which is to be compared with Mr. MacGill's average for steel hubs of about 0.12, a difference of 300 per cent. To take actual cases, the average of a great many tests of pressure to force car wheels on axles with about 5-in. bore and 6-in. length of hub, with an allowance of one mil per inch, is about 20 tons, and with an allowance of two mils per inch is about 40 tons. Mr. MacGill's table includes a great many cases of steel hubs from about 4.5 in. to 5.5 in. with an allowance of one mil per inch and his average pressure is about 50 tons. In the paper previously alluded to, an average test figure was given for force to press a rather thick steel hub, of 1560 lb. per inch of bore and per inch of hub length, for an allowance of one mil per inch. This gives for the above wheels with one mil per inch, about 23 tons. I know of some cases where values about 40 tons have been actually obtained, and they have been ascribed to inaccuracies of machine work of hub and shaft.

The test on which the figure 1569 was based and those giving the value of 20 tons force were with ground shafts and carefully reamed holes. A shaft or bore with ordinary machinery may be out of round or out of straightness or have other irregularities amounting to several thousandths.

Possibly Mr. MacGill's coefficients and forces are for ordinary machinery, and the lower values are for cases, with greater accuracy. The lower figures given are for lubrication with white lead or something similar. It is to be presumed that Mr. MacGill used a lubricant.

The formulae and methods used in the paper already quoted are identical with those of Mr. MacGill. In the writer's paper the case taken was for a solid or hollow shaft with a steel hub. Mr. MacGill takes a solid shaft with hub of any material, and values for a steel hub equivalent to the above are obtained by using steel coefficients. Mr. MacGill used 0.25 for Poisson's ratio. The value is probably nearer 0.30, but the effect is very small.

Mr. MacGill rightly concludes that large force fit allowances are not necessary in usual cases. However, in cases where they are necessary, as in high-speed wheels, they cannot be objected to because of excessive hub stresses unless the formulae show large stresses. For proportionately thick hub, the stresses with one mil per inch of bore allowance, are the same regardless of diameter.

It is to be noticed that the maximum effective stress in the hub is not simply the tangential stress, but is shown by the maximum shear theory to be the sum of the tangential and radial compressive stress. This is $\frac{EJ}{D}$ when shaft and hub are of the same material. The sum of Mr. MacGill's stresses will be found to be $\frac{EJ}{D}$ for steel. It may also be

[1] Increase of Bore of High-Speed Wheels by Centrifugal Stresses, Sanford A. Moss, Trans.Am.Soc.M.E., vol. 34, p. 909.

noted that the ratio of the radial and tangential stresses when hub and shaft are alike is

$$\frac{R_1^2 - R_2^2}{R_1^2 + R_2^2}$$

Harry M. Lane wrote that his company's records comprise data upon about 10,000 pressed fits, which go back about 20 years, and he had found it gratifying to note that they embrace all the data possible, there being 24 facts recorded with regard to each pressed fit, including diameter and length of hub into which the shaft is forced, and material of which the hub is made, area of fitted surface and the pressure at the first, second, third and fourth quarters of the length of the fit, which show the effect as recorded by the pressure of varying lengths of fit in each particular case without requiring comparison of different tests.

Before making these records they sometimes had trouble with loose cranks and crankpins, but since beginning the records these troubles practically ceased.

In common with others, they used to attempt additional security in the fastening of crankpins by riveting the pin over at the back of the crank, by screwing it up at the back with a thin, fine-threaded nut or by driving a taper key through slots in the crankpin and its boss

Of course, if the pin does not fit the hole, none of these makeshifts are effective, and if the crankpin is a fit, they are unnecessary. For last twenty years it has been the company's practice to make a dependable fit of the crankpin and let it go at that.

John Riddell spoke of the necessity experienced in the practice of the General Electric Company for varying the allowance for fits in order to meet the conditions existing. In the case of turbine engines it might be necessary in some cases to make a much greater allowance, due to the high speed at which the turbine was to operate, with consequent expansion of the wheel, than in another case where the turbine was to run at slower speed. As a specific instance, on a shaft 23 in. in diameter, an allowance of 0.020 in. was made for the fit. On this particular piece of apparatus it was calculated that when it revolved at 20 per cent above normal speed, the bore would become 0.017 in. larger, or in other words, there would be 0.003 in. left for fit at this speed.

This phase of the subject was treated by Mr. Sanford A. Moss[1] of the company's works at Lynn, Mass., who has gone into the matter carefully and treated it mathematically.

A. B. Carhart (written). It may be proper to suggest that in making calculations for forced fits, the surface of the contact area is a very important factor. The formulæ assume contact of the entire area of the shaft and of the bore. We all know how seldom this is actually realized in practice, because of the irregularities of any machine operations. In railroad shops, in the pressing on of car wheels it is surprising to see the approximation to accurate size and taper that will sometimes pass for satisfactory work and be forced into a fit. I cannot believe that in some cases any considerable part of the total area is actually in contact; yet some of such forced fits prove themselves to be reliable, durable and dependable in service.

More exact information should be required concerning some forced fits as for example in the pressing of car wheels upon axles for use in transportation service. I believe that formerly there was ground for complaint concerning wheels that would either work loose or would split in the hubs, and the manufacturers were called upon to replace wheels claimed to be defective or to pay the expense resulting from failure. Consequently it became of great importance to them to show that the workmanship in any case was satisfactory and that the fit was proper. It was necessary to know that there was proper area of contact, that sufficient power was applied to insure a permanent job, and especially that the pressure was not so excessive as to cause strain within the hub. It is as serious and as troublesome to have car wheels crack from over pressure in making pressed fits, as it is to have them run loose; either fault is a serious one.

Consequently it is now common practice to have a record made in the shop of each fit at the time it is pressed on. Special recording gages are used, which automatically trace a diagram of the pressure applied at each stage of the fit, indicating at the same time the forward movement of the ram of the press that forces the axle into the hub of the wheel. The record begins when the first contact is made, where the pressure begins to be appreciable, and as the axle moves forward, in pressing on the wheel, or in any shaft fitting, the actual gage pressure is recorded at each inch of movement, until the wheel comes to the shoulder or to the final position, and the maximum thrust applied there is also recorded. Such a chart record can be filed away, marked with the number of the job and of the wheel, and the shop has proof, in the future, of a proper and accurate fit, or of any sudden rise in the pressure at any point owing to a jam due to irregularity of the taper or to inaccuracy of the diameters concerned in making the fit.

The Author. The original object of my paper was to prove that "it is not necessary and may be dangerous to increase the allowance on pressed fits, with the diameter of the shaft." As stated, the tension stress, radial pressure and coefficient of friction were calculated some time after the records of the fits were made. The calculations were made primarily to arrive at a proper basis for establishing standard force fit allowances for ordinary machine shop practice, where high centrifugal forces and extremes in temperature need not be taken into consideration. In my judgment the results of these calculations uphold my claim.

I am pleased that the formulæ used meet the approval of Mr. Moss. For the sake of simplicity Poisson's ratio was taken at 0.25 for both cast iron and steel, since the use of different values has no appreciable influence on the result. The value of E for cast iron was kept constant at 15,000,000 partly for the same reason, and partly because where greater allowances are used and E diminishes, these allowances will bring the cast iron into the region of dangerous stresses, especially if hard key driving should be added to excessive allowances.

As to the coefficient of friction it is somewhat difficult to draw reliable conclusions from the figures obtained by the formula used.

Mr. Lane is the author of the paper referred to in the following quotation: "In but one of the papers noticed is there any reference to the diameter and length of the hub into

[1] Increase of Bore of High-Speed Wheels by Centrifugal Stresses, Trans. Am. Soc. M.E., vol. 34, p. 895.

which the shaft is forced or the material of which the hub is made."

In answer to Professor Sweet's question: "Ought not a shaft 8 in. in diameter take pressure four times as great to make a good force fit as one 4 in. in diameter? Will the same allowance give this?" I think not, and my records show that it does not. If this were the case an allowance proportionally less would be logical.

In all cases the surfaces of the fits covered by my table were lubricated with white lead and linseed oil before being pressed together. Too much care cannot be taken in making the surfaces of the fit true and smooth and in the keeping of an exact record of each fit made, possibly with a diagram showing the pressure at different stages as suggested by Mr. Carhart and Mr. Lane.

STANDARDIZING MACHINERY

By Fred H. Colvin, New York

Member of the Society

The advantages of standardization of parts which are or may be used together are becoming more and more apparent in all manufacturing and are now being considered by builders of such machines as lathes, planers, milling machines, etc. The question is how far can this be carried, for if carried too far, it might become a detriment rather than a help.

The builders of milling machines decided some years ago upon a standard of capacity, so that a buyer knows that a No. 2 miller of nearly all standard makes, has a table movement of 28 in. by 8 in. This does not, however, say how much power each machine has nor specify its size of spindle or similar parts.

Lathe and planer builders give nominal sizes in inches and feet, but there is no way of knowing from a list of a 14-in. lathe whether it swings 15 or 16 in., or whether a 36 in. by 36 in. planer will take in 37 or 38 in. between housings and under the rail. One effect of this is to allow a lathe that will actually swing 16 in. to be listed as and sold for the price of a 14 in. without the odium of cutting price. Some over size allowance must, of course, be made, but the general opinion seems to place this at not over 1 in., so that a 14-in. lathe will swing over 14 but not over 15 in., with the same allowance on planers and other machines.

After standardizing the work-holding capacity of machines, the question of what parts can be standardized to advantage must be considered. How far is it desirable to go, even were standardization not an extremely difficult proposition, and is it desirable to standardize any parts which are not used interchangeably in the modern shop? Assuming that these are the only parts to standardize, which parts are they?

Slots which are used to hold fixtures, as in milling machine tables and in planers, fall easily in the list of desirable parts to be standardized and this might easily be extended to lathe carriages, boring mills and other machines to which fixtures are attached. The adopting of a few sizes of T-slots and the apportioning of a definite size to certain sizes of milling machines, would enable fixtures to be transferred from one make of machine to another of the same size. Should it happen to be desirable to use this attachment on a large miller or on a planer or boring mill it might be necessary to use adapters. These, however, could also be standard. Definite T-slots could be assigned to 36-in. and other sizes of boring mills, etc., these being determined by the experience of the user as well as the maker. The exact size, however, is not of so much importance as the fact that they be standardized.

Standard bolt and cap-screw head sizes are a great convenience. The machine with a single wrench to fit all bolts, tool block, carriage stops, etc., is not often impossible, if it be made double ended, and while it may not be advisable to limit design by standardizing the size of bolts on a 16-in. lathe, there are probably many cases where they might be interchangeable without detriment. Beyond this, the problem becomes increasingly difficult.

There are some who advocate the standardization of lathe spindles, bearings and noses, but this seems to be treading on dangerous ground as well as being of doubtful utility. While there may be cases where it is convenient to be able to interchange chucks and face plates, these are few and far between in modern manufacturing. It may be a convenience in the jobbing shop, but it is seldom used elsewhere, and is not to be considered where accurate work is to be done. Those who have tried know that it is impossible to secure really accurate work unless a piece is finished at one setting of the chuck, in many cases a special chucking plate or seat being turned out whenever a new lot is to be done.

Light work does not require a heavy lathe nor will it stand the heavy cuts of which the modern lathe is possible, so that unless we have standards for light and heavy lathes, it would be a hardship rather than a benefit. The sizes of spindles and bearings should be left to the designer and the buyer can select whatever he needs.

After we have considered the standardization of parts we can well spend a few moments on the question of names of machines and parts, especially the latter, for while many of us believe that the present naming of many of our machines is crude if not incorrect, there is little confusion caused by mistaking the kind of machine which may be meant, either in conversation or in writing. But when it comes to parts of machines, it is a very different story. Nearly every maker and user knows of exasperating delays in supplying and securing parts of machines owing to a lack of uniformity in names. This often necessitates the writing of several

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letters, and with machines standing idle the cost of delays mounts up into large figures during a year.

Many manufacturers supply a list of parts of their machines and in most cases illustrate the part itself so that there can be little difficulty in distinguishing it. Unfortunately, however, few shops keep these lists where they are handy, and when it becomes necessary to send for a repair part they designate it by the terms used in that locality for similar pieces, as is very natural.

A little attention in the naming of machine parts would obviate much of this difficulty. It is a process of education, and if we will begin by naming parts according to the service they perform, much difficulty can be eliminated. This is already done to a considerable extent, as in the use of such terms as "lead" screw, "feed" rod, and similar names. Such names, however, as "cat head," "tumbler gear," "planer harp," etc., form a separate language which must be learned the same as Sanskrit or Esperanto.

Another example of confusion in this way is the naming of the handles by which a turret slide is advanced to the work. This is commonly known as a pilot wheel on account of its resemblance to the wheel used by a pilot in controlling the course of his vessel. In some parts of the country, however, it is known as a "turn-stile" and a "spider," although the latter name has a very different meaning to most of us.

If we could devise some means of designating the machine parts by the work they perform without having the names too cumbersome, it would seem as though the matter might be simplified, and at the present time, this appears to be more important than the naming of the machines themselves, however badly they may be in need of a more rational designation.

Another field of standardization that promises important benefits to the user is that of the electric motors designed to be applied to machines. At present, there is no uniformity in speeds, powers and general dimensions. Thus it is practically impossible to design the details for attaching a motor to a machine until the precise specifications of the particular motor to be used are obtained from the motor builder. A great benefit would be conferred upon all motor users if the following points could be standardized: the voltage and speed for direct-current motors from, say ½ to 50 h.p., the voltage, cycles and speeds for alternating-current motors for the same range of power, the outline of the feet with the location of bolt holes, the diameter of the armature shaft, size of keyway and distance from shaft shoulder to center of figure of motor, the distance from the center of the shaft to the bottom of the feet, and the general clearance dimensions for the outside of the motor. In 1910 these details and others were considered by a committee of the National Machine Tool Builders' Association, coöperating with a similar committee of the Association of American Motor Manufacturers. A number of features were recommended, but these have not been put into effect. Meanwhile, motor users are subjected to annoying delays and difficulties in applying motors to machines.

It must not be thought that the standardization of machine details is a difficult matter. It is much more difficult in theory and in consideration than in adoption and application. Some ten years ago, the United Shoe Machinery Company established a department to standardize details of the 250 or more machines that they built at that time. The machines under consideration had been built over a period of 36 or 40 years by a large number of different designers in many different shops. Thus uniformity did not exist there. In fact, it is safe to say that there was less uniformity in regard to general details of these machines than will be found among the details of machines of the same general class built to-day by representative manufacturers. For a generation, shoe machinery had been leased on royalty to the shoe manufacturer, and the machinery building company was under obligation to furnish spare parts. Thus, changes in detail of necessity might interfere seriously with a well-established business. However, the advantages for standardization were so great, that the possible disadvantages were overweighed and the work started. It was carried through to completion during a period of about a year, and, although at first some little confusion and difficulty occurred in furnishing spare parts to old machines, these difficulties rapidly disappeared and the advantages of uniformity became apparent.

Standardization must never be undertaken in a weak-kneed fashion. It must be approached courageously, with the exercise of good judgment, but an appreciation that difficulties, if they arise, will be only temporary in character. It is far better to have some difficulty for a year or two than to hamper the use and applications of machines for a generation. Even though it is impractical to change the details on existing machines that have been on the market for some time, the newer details can be employed in fresh designs, which are constantly being brought out. After the lapse of a few years, the old order of things has disappeared and the new is firmly installed with its attendant advantages. The attitude should be one of attack when such a problem is presented, attack with the determination of finding one detail and making that uniform, instead of giving prolonged consideration to the possible difficulties and disadvantages.

DISCUSSION

LUTHER D. BURLINGAME (written). I agree with the spirit of this paper as to the matter of standardization, for one reason, because it takes a conservative position that will not hamper and be a check to improvements in machine designing. I believe that the standardization of work-holding capacity is desirable and feasible, and would be an entering wedge where there could be standardization without any question of blocking progress.

This could be followed by the standardization of work-holding means, another step where it would seem that some practical progress can be made.

I am pleased to see emphasis put on the standardization of motors because, while it may seem like asking "the other fellow" to do the standardizing, it is very important, from the machine builders' standpoint, that motors should be brought to some uniformity, especially in the provision for attaching to machines.

Referring to the standardization of bolts, nuts, and other holding parts that must be adjusted by the wrenches, it seems from my own experience more important to standardize the wrenches, having as few sizes as possible on a given machine, even where to do so means special bolts and nuts.

I am also interested in the emphasis that is placed on the matter of naming the parts, because that is a matter at present causing constant trouble, often requiring extended correspondence to find out what is meant. It would help to bring about uniformity if we had an up-to-date mechanical dictionary. The fact that national organizations are taking this matter up is encouraging, as promising results for the future. Our mechanical press has done much along this line in gathering information as to names used and in bringing about the use of uniform terms.

F. DeR. Furman commended the paper from the educational point of view. The many names for the same fittings used in different sections of the country and such odd and peculiar names as those cited by the author, "cat head," "tumbler gear," etc., which are almost meaningless to the student, all help to block progress by increasing the amount of material to be taught and explained. Fixed names to designate fixed parts would help in the advancement of educational work.

A. B. Carhart (written): The dark ages when each manufacturer wilfully chose special threads, special connections and special dimensions, are passing. The tendency is now to meet upon common ground so that the purchaser may freely determine the relative merits of the different products offered.

The suggestions in the two concluding paragraphs of the paper have undoubtedly appealed to everyone engaged in manufacture. Almost every month in the year some piece of apparatus is brought up for review to weigh the advantages and disadvantages involved in a proposition to change or to standardize. If it is only a question of nomenclature, it can often be settled in the drafting room or by the engineering staff. I think Mr. Colvin is especially helpful when he suggests, at the close of his paper, that there should be greater courage in such matters, and that we should avoid giving too long consideration to the difficulties and the disadvantages in changes that may seem to be worth while.

The inclination to name parts by the work they perform is a commendable one, and should be extended further than we have done in this country, so long as we do not fall into the temptation of using words such as some of the compound German names. I think the greatest influence toward such reform lies with the trade papers. Their example will assist much in any improvement in this direction, and undoubtedly their influence, in correct usage, is greater than ever before in the history of machine tool building.

Fred J. Miller (written). Little can be done toward obtaining standardization of machine construction unless we give to the makers of such machines a commercial incentive to adopt standards. If we merely read papers and discuss the desirability and general loveliness of having standards, we shall never bring about their adoption. We must recommend standards by some authority, so that such standards can be known to exist, and so that a designer or producer of any kind of machinery who is considering a dimension that will affect, either by connection with other machines, or in any other way, the matter of standards, can refer to a definite standard that has been established; otherwise he may make it just enough different to constitute an addition of a new variety that could as well have been avoided.

The Society has a committee on Engineering Standards which has been in existence for some time. I do not remember how it is constituted, but it seems very desirable that the members of this committee should be chosen with a view to their acquaintance with the various lines of machines, such as engines, motors, machine tools, etc. Then if each member of the committee studies carefully the points pertaining to his field and their connection with those in other fields, and then, where possible, the whole committee recommends a standard for such things as a standard may be applicable to, it may lead to good results.

That method will not in most cases result in immediate conformation to such standards, because the various builders will have their drawings, patterns, catalogues, etc., and the new standard may not come into use except as newly designed machines may be brought out.

We have had an interesting experience in the Remington Typewriter Company. We have four factories each making one or more different typewriters. We found that no attention had been paid to the reduction of the variety of screws made for these machines. About 25 to 35 taps were used for each machine, each tap differing in size, in pitch, or in both, from any other, and no two factories used the same form of thread. A committee was appointed to study the matter and it found that the commercial incentive, to which I have referred, did not exist for making any change in the machines already on the market, screws for which were in our branch offices all over the world, and stocks of the same screws and tools, and gages for producing them, in the factories. The investigation did lead to a different practice with the newer models, however. When a new machine was put on the market about a year ago or over (sold exclusively in Europe) only seven taps were used in the entire machine, instead of 35; the seven answered every purpose, and of course, there is a very great advantage from the manufacturing as well as from the repairing standpoint—it simplified the whole matter.

When we came to make still another new model, in another factory, we asked that they confine themselves not only to the list which our committee had prepared, but that they confine the screws to be put in the new machine to screws that were already included in the machine we had previously made, and that had been on the market for a year or so. They found they could easily do that, and used only four different taps in that entire machine. These screws conform to a certain portion of the list recommended by the committee appointed by the society to recommend standards for machine screws.

That is an example of working the thing out where a num-

ber of factories are under one ownership and control. There is, of course, no such control that can be exercised in the general field, but a committee such as we have acting for this Society can at least define standards, and call attention to them in a way such that when a man is doing a new thing, and it is a question of whether he will conform to the standard or do something else, he will generally prefer to conform to the standard. In that way we shall accomplish something along the line of standardization.

JAMES GREEN. There is one point with respect to standardization that would greatly help the operator of the machine. That is the direction of motion of the handles for adjusting parts. On one machine the operator turns the handle and a spindle will go down; on another similar machine he will turn a handle in the same way and a spindle will go up, which is confusing to him. Another point is with regard to special heads for screws. It is the practice of one manufacturer to use the same size heads on screws of different diameters in so far as it is practicable to do so, so that the same wrench may be used on different screws and on various machines.

GILBERT S. WALKER said he had written a good many Government specifications and had a rule that seemed to work pretty well in practice. He tried to word the specifications so as to let in the regular products of three good manufacturers and to keep out as many of the others as he could. The reason for three was that the regulations require the securing of at least three bids. When there were too many bids good articles were less likely to be obtained.

D. M. WRIGHT[1] considered the standardization of mechanical nomenclature to be closely allied to the matter of standardizing machinery, and thought that an investigation of the work of the nomenclature committee of the National Machine Tool Builders' Association in this direction might suggest to the Society the formation of a similar committee. The Nomenclature Committee of the National Machine Tool Builders' Association would be glad to co-operate with the Society if this were done. A comparison of the various mechanical magazines of today with those of five years ago will show that practically all of them have very materially changed their index and their editorial language, and that a large number of the advertizers have also changed their advertisements to use the preferred nomenclature. The manner of changing seems so simple and results in so much good it is hoped that the Society will look favorably upon the formation of a Nomenclature Committee.

[1] Secy. and Treas., The Henry & Wright Mfg. Co., Hartford, Conn.

THE AUTHOR. It is gratifying to note the tendency toward standardization as shown by the discussion of the various points brought out. The suggestion of Mr. Miller, that we must give a commercial incentive toward the adoption of standards, is particularly helpful. As he points out, we can hardly expect to affect the design of machine already on the market, but a little consideration would do much toward standardizing new products.

The commercial incentive can best be supplied by the consumer asking or even demanding products which embody such standard dimensions as may be considered good practice and recommended by the Society or others. When enough consumers in ordering machine screws, for example, specify A.S.M.E. standard, screws of this kind will be carried in stock by all dealers.

REPORTS OF COMMITTEES

STANDARD SIZES OF CATALOGUES

The Committee has made an extensive investigation of the various sizes of catalogues in common use, and has had correspondence with many paper manufacturers, printers, advertising agents and makers of filing boxes and cabinets, as well as with manufacturers of machinery and supplies. The general conclusions it has reached may be summarized as follows:

a There is a universal opinion that catalogue sizes should be standardized. It is not necessary to give any reasons here for this opinion, as it is all on one side.

b The standard of 6 in. by 9 in. has for so many years met with such wide acceptance, probably two-thirds of all the catalogues that are now made being either that size, trimmed as closely to exact size as possible, or within ¼ in. of it in one or both dimensions, that it may be considered as too well established ever to be abolished.

c The 6 in. by 9 in. size is too small for many purposes, and it is necessary to have for some purposes a size which is about 8 in. by 10½ in. or 8½ in. by 11 in.

There are objections to having both considered as standard sizes, and as there is an increasing tendency to the use of the larger size the Committee recommends that 8½ in. by 11 in. be the standard. Electrotypes 4 in. by 7 in., which are commonly used for 6 in. by 9 in. pages, may conveniently be used, two on a page, on an 8½ in. by 11 in. page, but they are too large for the 8 in. by 10½ in. page.

The 8½ in. by 11 in. page folded twice makes 3⅞ in. by 8½ in., which is a convenient size for a long folder.

d The 9 in. by 12 in. size has been adopted by a few for very large catalogues. While it is generally acceptable for technical and trade journals, it is rather too large for a catalogue, unless it is to be a large cloth-bound book, to be placed on a shelf and not filed in a cabinet. It should, therefore, not be recommended as a standard for common use.

The following extracts from some of the letters received show the variety of opinions that exist as regards the sizes that should be adopted:

Matthews-Northrup Works, Buffalo, N. Y. Paper stock is made in sheet sizes 25 in. by 38 in. Since cuts have been made and tabular pages set for years to fit 6 in. by 9 in. it should prove very expensive for many firms to change. An opportunity is afforded by the 9 in. by 12 in. size to run the text descriptive matter or tabular panel of sizes and prices immediately under the illustrations on the same page. The 8½ in. by 11 in. size works out in good proportions. These three sizes seem to be the only ones that need be planned for.

Robert L. Stillman, New York. I suppose there are more catalogues made 6⅛ in. by 9¼ in. or 9⅜ in. by 12¼ in. than any other size, because they both cut from 25 in. by 38 in. paper which is of standard size, allowing ⅛ in. for trim.

The 33 in. by 46 in. size would make 8⅛ in. by 11¼ in. It might be reduced to 11 in. to get it within the standard letter size.

Ticonderoga Pulp & Paper Co., New York. It would be much to the advantage of every one if all catalogues could be standardized to a certain size. It would be a great assistance not only to the paper manufacturer but also to the dealer and printer, as in that case the dealer could carry in stock standard sizes and could supply paper promptly, and printers would not then have to wait for paper to be made especially.

Frank Presbrey Co., New York. Sent samples 6¾ in. by 9¾ in., and recommended it as the size used in all standard magazines. In reference to letter size, 8½ in. by 11 in., if a movement be inaugurated which will result in making up to this size all catalogues and monthly bulletins a great deal will be accomplished.

Collin Armstrong Advertising Co., New York. As far as our experience goes 5½ in. by 8 in. is the most convenient size. Anything near 8½ in. by 11 in. would in our opinion be too large to be handled easily, would be apt to go to pieces quickly and probably not be kept carefully by the recipient, as would be the case with a smaller book.

F. F. Coleman, Publicity Manager, Lidgerwood Mfg. Co., New York. All publications except catalogues intended for filing should be eliminated from consideration. The best size for catalogues is 9 in. by 12 in. upright. Personally, I would abolish the 6 in. by 9 in. size.

J. Horace McFarland, Harrisburg, Pa. In the nursery trade the 6 in. by 9 in. size does not permit such attractive illustrations in an economical manner as the growing vigor of selling campaigns required, and there is a great disposition to get away from anything of a standard size and to make the catalogue different.

Hammacher, Schlemmer & Co., New York, are working on a new edition of their catalogue which will be 9 in. by 12 in. For a number of years they used 5½ in. by 7¾ in., but it is too small for a book of say 1200 pages. For pamphlets and smaller sizes will use 6 in. by 9 in.

Manning, Maxwell & Moore, New York. Books for general mechanical goods, both small and large should be 6 in. by 9 in. wherever it is practicable. In many cases a larger sheet is necessary to take the proper size cut to show important small details.

General Electric Company, Schenectady, N. Y. We use and recommend 8 in. by 10½ in. catalogues as standard. The width of page is valuable for displaying illustrations and tabular matter. Our standard letter paper is 8 in. by 10½ in. Our standard photographic plate is 8 in. by 10 in.

The Yale & Towne Mfg. Co., New York. C. L. Redfield, Adv. Mgr.—Printed matter may well be any of the following

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sizes for reasons given: 6 in. by 3⅜ in. for folders, because this size just fits the small Government envelope which is still very largely in use among business people; 8 in. by 3½ in. for folders and small booklets, because it just fits the No. 9 Government 2-cent envelope and makes it very easy to use such printed matter to accompany correspondence; 6 in. by 9 in. for small catalogues, as we have been led to believe that this is more acceptable to the machinery and other trades; 8 in. by 10½ in. for sheets which accompany correspondence, as this is the size of our letter head; 9 in. by 12 in. for our more important catalogues, this being the accepted size with the paper makers and is carried in stock.

From a *Circular of Advice* issued by the American Institute of Architects, April 1913, manufacturers are earnestly urged to adopt a standard size of 8½ in. by 11 in. for all catalogue matter which they desire an architect to keep for reference, this being the size which can be most readily filed in the standard letter files of the day. For convenience in indexing, it is essential that all catalogue matter should be divided into sections, so that the sections of different manufacturers treating on the same subject may be grouped together. This means that only one article should be treated on a single leaf, and that no leaves should be bound together except where they refer to a single article or variations of that article.

A list of 927 catalogues measured for the Technical Publicity Association showed that there were no less than 147 different sizes. Dividing the 147 sizes into eight groups there are the following:

3 to 3¾ by 5 to 9, sixty of which 34 are 3½ by 6.
4 to 4¾ by 5¾ to 9¼, one hundred and twenty of which 21 are 4 by 6 and 26 are 4 by 7½.
5 to 5¾ by 6½ to 9¼, one hundred and eighteen of which 15 are 5 by 7 and 17 are 5 by 7½.
6 to 6¾ by 7 to 10½, four hundred and forty three of which 325 are 6 by 9 and 23 are 6½ by 9½.
7 to 7¾ by 7 to 11, eighty-three of which 20 are 7 by 9 and 17 are 7 by 10.
8 to 8¾ by 9½ to 12, sixty-four of which 15 are 8 by 10½ to 11, and 16 are 8½ by 10½ to 11½.
9 to 9¾ by 10¼ to 12½, thirty-three of which 17 are 9 by 12.
10 to 11 by 11 to 14½, six.

The first four groups contain 80 per cent, and the last four groups only 20 per cent of the whole number of catalogues.

RECOMMENDED SIZES

	Inches
Index card, standard	3x5
Index card, larger sizes	4x6 and 5x8
Folders:	
Small	3⅜x6
Large	3¾x8½
Catalogues, standard size	6x9
Bulletins and large catalogues, standard	8½x11

In addition to the recommendation as to sizes the Committee would also recommend the following:

a For paper covered catalogues intended to be permanently filed, the edges, including the cover, should be trimmed to exact size. No fancy deckled edge or dark tinted paper should be used.

b Overlapping edges of the cover are permitted when the catalogue is bound in covers stiff enough to support its weight in boards or heavy card paper.

c The title should always be printed on the exposed back of the catalogue whenever possible, for the purposes of identification. When the book or catalogue stands on its lower edge the title should be read from the top downwards, as in Fig. 1.

d Every catalogue should have a date on its title page.

e A standard size index card 3 in. by 5 in. should be enclosed in each catalogue, with the title of the book and a brief statement of the character of its contents printed on it.

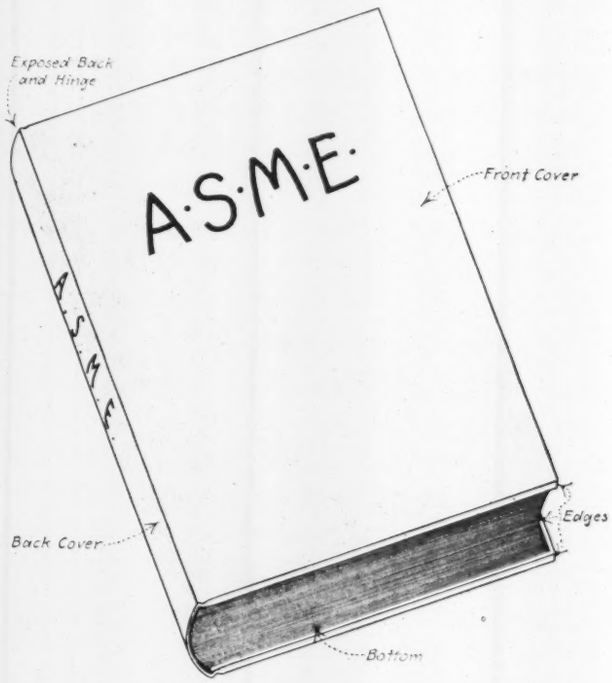

FIG. 1 SHOWING ARRANGEMENT OF TITLE ON BACK OF BOOK

Catalogues, extra large, and technical press	9x12
Transactions of societies, pamphlets, etc	6x9

PAPER BOXES, DRAWERS AND VERTICAL FILING CABINETS

(Inside Measurements)

For 6 in. by 9 in. catalogues, pamphlets and 9 in. by 12 in. papers folded once	6½x 9¾
Paper boxes and drawers for larger sizes	9½x12⅛
Vertical files for large sizes	10x12⅛

Fig. 2, which gives a clear idea of the relation of these several sizes to each other is drawn to scale, showing them superposed.

FILING BOXES AND CABINETS

Jesse Jones Paper Box Co., Philadelphia, Pa. A box that will hold a sheet 8½ in. by 11 in. is by far the most in demand.

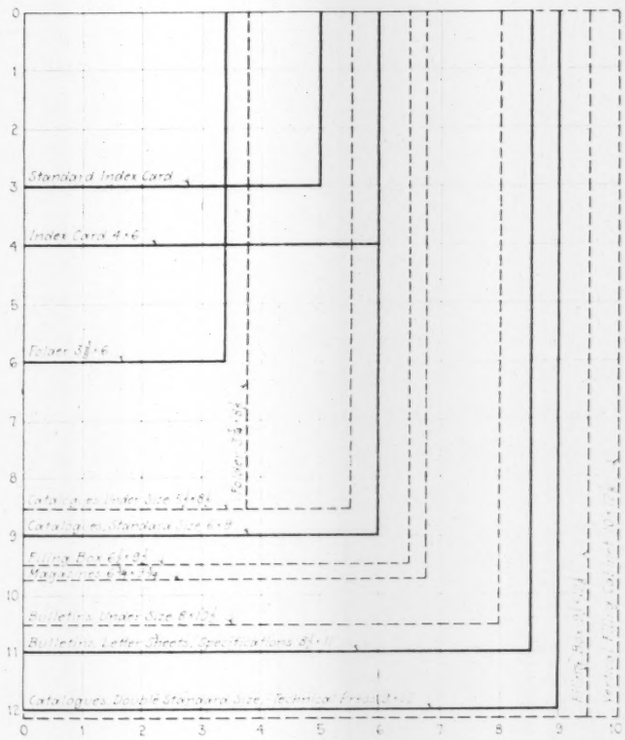

FIG. 2 RELATION OF CATALOGUE SIZES

Various makers of filing cabinets give the following sizes, in inches, of drawers (inside measurements):

Correspondence files, 9⅞ by 11 9/16, 10 by 12, 10½ by 12⅛, 10 7/16 by 12.

Legal cap files, 9⅞ by 14⅜, 9½ by 15, 10½ by 15¼.

Invoice files, 7½ by 9½, 7¾ by 9¾, 8 by 10, 8¼ by 10 1/16.

The 9⅞ in. by 11 9/16 in. is too short to take a 9 in. by 12 in. paper. There seems to be no reason for making the height more than 10 in. as no letter paper is over 8½ in. wide. A size of 10 in. high by 12⅛ in. wide would seem to be the best for all large-size catalogues. It would hold two 6 in. by 9 in. side by side, although the filing of 6 in. by 9 in and 9 in. by 12 in. papers, together in the same drawer is objectionable, as the smaller sized papers have a tendency to lap over on each other and thus to occupy more space than they should. The extra inch in height gives ample room for division cards and tabs. The legal cap and the invoice files are not suitable for any of the standard sizes of catalogues.

A size suitable for the 6 in. by 9 in. catalogue does not appear to be in the market. If one were made with drawers about 6½ in. by 9¾ in. it should have a ready sale. The drawer would be more easily handled than the 10 in. by 12⅛ in. size.

Respectfully submitted,

WM. KENT, *Chairman*
J. R. BIBBINS
M. L. COOKE
W. B. SNOW
} *Committee on Standardization of Catalogues*

October 25, 1913.

STANDARDIZATION OF PIPE THREAD GAGES

The purpose of the Committee on Standardization of Pipe Threads has been to fix manufacturing limits for the use of the Briggs standard pipe thread gages when tapping fittings or flanges, so that pipe cut to the Briggs standard might always enter a definite number of turns. Although the Briggs standard is used almost universally for pipe threads in the United States, the method of its use for female threads has not been established, in that no determinations have ever been made of the standard depths to which hand plug gages should enter. This has resulted in much confusion in the past, inasmuch as pipe threaded to the Briggs standard is liable to vary in the number of threads it would screw into fittings tapped at different shops. This tendency is so marked that pipe fitting is handled in practically all cases by sending the flanges to the shop where the pipe is being cut, in order to be sure of satisfactory results.

This matter is conceded to be a simple one in that all it requires is an agreement among the manufacturers of fittings as to the point at which a ring should be attached to the gage, to establish, when the gage is inserted by hand, the proper depth of the thread. To this end the committee has met in conference with representatives of the manufacturers and also of the committee of the Society on International Standards for Pipe Threads. C. A. Olson, Chairman of the Manufacturers' sub-committee on Pipe Thread Gages, stated at this meeting that his committee had made a study of present practice among the various manufacturers and had adopted tentative definitions of the gages to be used, of the proposed thickness of ring gages acceptable to the manufacturers, and of the tolerances to be allowed. These he submitted as follows:

The gages shall consist of one plug and one ring gage of each size.

The plug gage shall be the Briggs standard pipe thread as adopted by the manufacturers of pipe fittings and valves, and recommended by The American Society of Mechanical

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Engineers in 1886. The plug is to have a flat or notch indicating the distance that the plug shall enter the ring by hand.

The ring gage is to be known as the American Briggs standard adopted by the Manufacturers' Standardization Committee in 1913, and recommended by The American Society of Mechanical Engineers, the Committee on International Standard for Pipe Threads, and the Pratt & Whitney Company, manufacturers of gages. The thickness of the ring is given in the following table. It shall be flush with the small end of the plug. This will locate the flat notch on the plug flush with the large side of the ring.

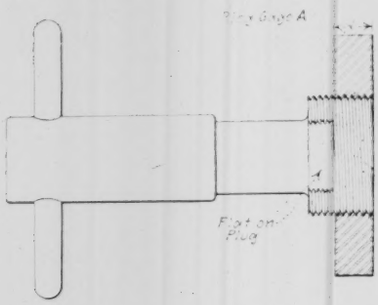

Fig. 1 View of Plug and Ring Gage

Pipe Size	Adopted Thickness of Ring Gage *A*
1/8	0.1801
1/4	0.200
3/8	0.240
1/2	0.320
3/4	0.339
1	0.400
1 1/4	0.420
1 1/2	0.420
2	0.436
2 1/2	0.682
3	0.766
3 1/2	0.821
4	0.844
4 1/2	0.875
5	0.937
6	0.958
7	1.000
8	1.063
9	1.130
10	1.210
12	1.360
14	1.562
15	1.687
16	1.812
18	2.000
20	2.125
22	2.250
24	2.375

REMARKS

The table above indicates the dimensions of the ring gage *A* shown in Fig. 1, which are the figures adopted by the Manufacturers' Standardization Committee.

In the use of the plug gage shown in Fig. 1, the notch on the plug is to gage, and one thread large or one thread small must be the inspection limits.

In the use of the ring gage, male threads are to gage when flush with small end of ring, and one thread large or one thread small must be inspection limits.

After consideration of the matter by the entire committee, it was voted that the table of sizes and tolerances submitted be approved as above, by the joint committee, and that there be deposited with the Bureau of Standards at Washington, D. C., a set of gages to be known as the American Briggs Standard for Pipe Threads, the expense of the manufacture of these gages to be provided for at a conference between the Manufacturers' Committee, the Bureau of Standards, and the Pratt & Whitney Company.

Respectfully submitted,

E. D. Meier, *Chairman*
George M. Bond
A. M. Houser
J. C. Meloon
Charles A. Olson
Peter C. Patterson
Henry G. Stott

Committee on the Standardization of Pipe Thread Gages

STANDARD THREADS FOR HOSE COUPLINGS

REPORT OF SUB-COMMITTEE ON FIRE PROTECTION

In considering the problem of the adoption of a hose coupling thread, it became a question whether to advise specifications which would show the extreme of mechanical strength without reference to the preponderance of designs of a less theoretical value in general use, or to seek for the introduction of a threaded coupling, the characteristics of which would most closely accord with the majority class, and at the same time prove to be an intermediary of such capacity as to accommodate itself to interchange with a large proportion of couplings not exactly conforming to its dimensions.

Accepting the latter method of procedure as promising the widest measure of success, a committee of the National Fire Protection Association undertook a special investigation of existing conditions, using the report of a special committee under C. A. Landy, chairman, in 1891, as a basis. After securing additional data they became convinced of the practical value of the specifications named in that report, and submitted as a standard coupling for 2 1/2-in. hose, one showing a diameter of 3 1/16 in. over male end thread with 7 1/2 threads to the inch, by the use of which it was practically demonstrated that couplings ranging in outside diameter from 3 1/32 in. to 3 5/64 in., with either 7, 7 1/2 or 8 threads to the inch, could be so modified as to couple-up in service with this suggested standard, and thus render over 70 per cent of the 2 1/2-in. couplings known to be in use, conformable

Presented at the Annual Meeting 1913, of The American Society of Mechanical Engineers.

to the proposed standard at small expense as to time, money or labor.

In elucidation of the essential features of this standard it was deemed wise to formulate specifications covering 2½, 3, 3½ and 4½-in. hose couplings, the inside diameters of which were to be in conformity with the sizes named, specific details relating to each of the standard sizes being shown in the printed specifications as follows:

SPECIFICATIONS FOR HOSE COUPLINGS

Inside diameter of hose, inches	2½	3	3½	4½
Number of threads per inch	7½	6	6	4
Male Couplings				
Outside diameter of thread *finished*, inches	3 1/16	3⅝	4¼	5¾
Diameter at root of thread, inches	2.8715	3.3763	4.0013	5.3970
Clearance between male and female threads, inch	0.03	0.03	0.03	0.05
Total length of threaded male end, inches	1	1⅛	1⅛	1⅜

The above are to be of the 60-deg. V-thread pattern with 0.01 in. cut off the top of thread and 0.01 in. left in the bottom of the valley in 2½-in., 3-in. and 3½-in. couplings, and 0.02 in. in like manner for the 4½-in. couplings and with ¼-in. blank end on male part of coupling in each case. Female ends are to be cut ⅛ in. shorter for endwise clearance, and they should also be bored out 0.03 in. larger in the 2½-in., 3 in. and 3½ in. sizes, and 0.05 in. larger in the 4½ in. size in order to make up easily and without jamming or sticking.

SUGGESTIONS FOR CONVERTING NON-STANDARD COUPLINGS FOR SERVICEABLE INTERCHANGE WITH THE NATIONAL STANDARD

The fact that the National Standard has received the unqualified approval of all the leading organizations concerned with water supplies and fire departments, forms a strong argument for its early adoption in all localities. In order to demonstrate that the question of expense in changing over to the standard is less serious than is often imagined, the following suggestions, contemplating a gradual change from non-standard to full standard equipment, are submitted in the belief that the comparatively light cost of such a procedure should not delay so important and beneficial an improvement in any town or city. These suggestions are intended to apply to the period of transition which must of necessity precede complete standardization.

Considering first the 2½-in. hose couplings and hydrant outlets in general use, we suggest that:

a Contracts for new hydrants should specify that the nipples be equipped with the National Standard Hose thread.

b Existing hydrant nipples should be replaced by standard nipples. This may readily be accomplished at comparatively small expense through the use of a special device or tool now on the market; or as a less satisfactory method, the nipples may be equipped with adapters having standard thread on the outboard end. These adapters should be fastened in position so as not to be readily removable.

c Fire engine nipples should be provided with adapters having standard thread on the outboard end. These should be secured in place so as not to be readily removable.

d In many cities and towns where the 2½-in. hose couplings, as well as the nipples on

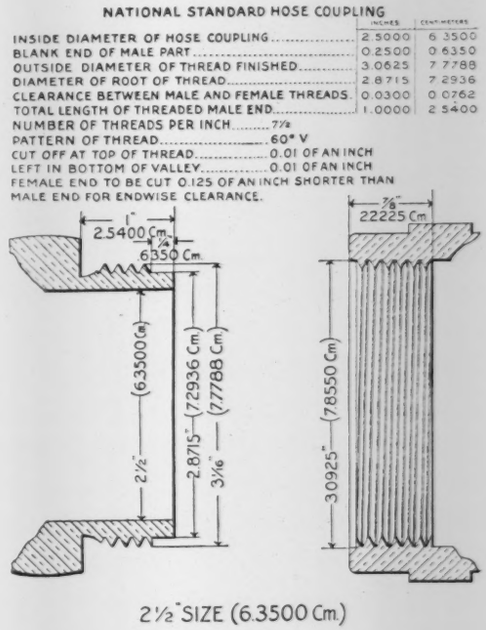

FIG. 1 DETAILS OF 2½-IN. COUPLING

hydrants and fire engine outlets, show 7, 7½ or 8 threads to the inch, wide variations occur in outside diameter over the thread of the male end of the couplings. If such variation does not exceed 1/32 in. below 3 1/16 in. (equaling 3 1/32 in.), or if the variation does not exceed 1/64 in. in excess of 3 1/16 in. (equaling 3 5/64 in.), it becomes feasible to render both male and female couplings adaptable for interchange with the Standard 2½-in. hose couplings (measuring 3 1/16 in. outside diameter on the male end and 7½ threads to the inch) by the use of an adjustable tap for the female end of the coupling, or an adjustable die for the male end of the

coupling, either tap or die having the same number of threads to the inch as the coupling or nipple to be treated.

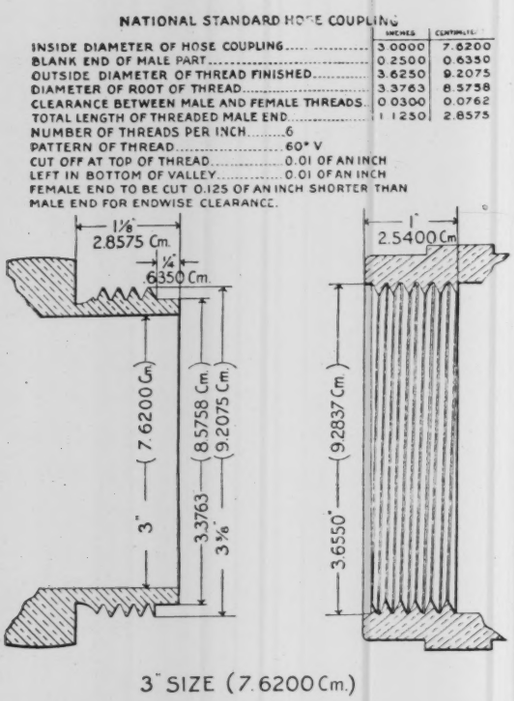

FIG. 2 DETAILS OF 3-IN. COUPLING

Any deviation within the limits named may readily and cheaply be overcome without the removal of couplings from the hose or of the nipples from the hydrant or engine. It may be well to emphasize the fact that in adapting the 7 and 8 thread coupling to interchange with the National Standard of 7½ threads, it is thus intended to provide an interim measure to serve until the standard has been fully installed, the reduced coupling being discarded as the hose wears out, and all new hose purchased to be fitted with the Standard couplings, thus securing a gradual and inexpensive method of standardizing the whole equipment of the city.

e Couplings of new hose, whenever purchased, should be the National Standard, and specifications under which new hose is purchased should always include a clause to this effect.

f Until all hose on hand has been provided with standard couplings or has been converted as suggested on the preceding page, a sufficient number of adapters should be carried on each hose wagon, so that the unconverted hose can be coupled up with the standard outlets of hydrants or fire engines.

g In view of the fact that 3-in. hose is coming into more general use, it is deemed advisable that such hose should be fitted with 2½-in. couplings having threads which conform to those on 2½-in. hose already in use.

It is believed that the total expense involved in a complete change from existing to standard conditions will not exceed the cost of the operations described in *b*, *c* and *f*, and that no further steps will be needed in any city save to order all new equipment of every description to be supplied with National Standard threads.

It is of course clear that a similar line of action, as noted in *a*, *b*, *c*, *e* and *f*, should be followed in the case of the couplings and hydrant outlets pertaining to the suction hose of the engines. While the cost will be

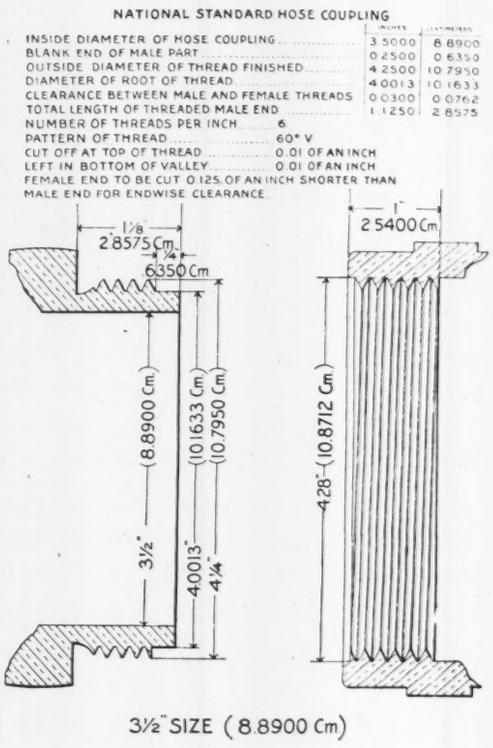

FIG. 3 DETAILS OF 3½-IN. COUPLING

greater per outlet, the outlets to be thus equipped will be much less in number than for the 2½-in. connections.

While the extremes of diameter in couplings as herein indicated appeal to this committee as being conservatively reliable for the treatment recommended, many instances of adaptation have been recorded wherein the deviations treated range as low as 3 in.

and as high as 3 3/32 in. with satisfactory results in service, thus strongly emphasizing the value of the "National Standard" as an intermediary or accommodation thread coupling of wide adaptability.

It is recommended that the Higbee style of cutting the thread be adopted hereafter in order to facilitate speed in coupling up and in avoiding crossing.

These specifications, covering the essential features for hose couplings and hydrant fittings for public fire service, have been agreed upon in joint conference with accredited representatives of a number of organizations and associations interested in or controlling this class of work. They will be known as the National Standard, and to date have been adopted by the following associations:

American Public Works Association, American Society of Municipal Improvements, American Waterworks Association, International Association of Fire Engineers, League of American Municipalities, Minnesota State Firemen's Association, National Board of Fire Underwriters, National Fire Protection Association, National Firemen's Association, New England Waterworks Association, North Carolina State Firemen's Association, Pennsylvania Waterworks Association, Virginia State Firemen's Association.

Respectfully submitted,

JOHN R. FREEMAN, *Chmn.*	*Sub-Committee on Fire Protection*
E. V. FRENCH, *Vice-Chmn.*	
ALBERT BLAUVELT	
F. M. GRISWOLD	
H. F. J. PORTER	
T. W. RANSOM	
I. H. WOOLSON	

NATIONAL STANDARD HOSE COUPLING

	INCHES	CENTIMETERS
INSIDE DIAMETER OF HOSE COUPLING	4.5000	11.4300
BLANK END OF MALE PART	0.2500	0.6350
OUTSIDE DIAMETER OF THREAD FINISHED	5.7500	14.6050
DIAMETER OF ROOT OF THREAD	5.3970	13.7084
CLEARANCE BETWEEN MALE AND FEMALE THREADS	0.0500	0.1270
TOTAL LENGTH OF THREADED MALE END	1.3750	3.4925

NUMBER OF THREADS PER INCH 4
PATTERN OF THREAD ..... 60° V
CUT OFF AT TOP OF THREAD ..... 0.01 OF AN INCH
LEFT IN BOTTOM OF VALLEY ..... 0.01 OF AN INCH
FEMALE END TO BE CUT 0.125 OF AN INCH SHORTER THAN MALE END FOR ENDWISE CLEARANCE.

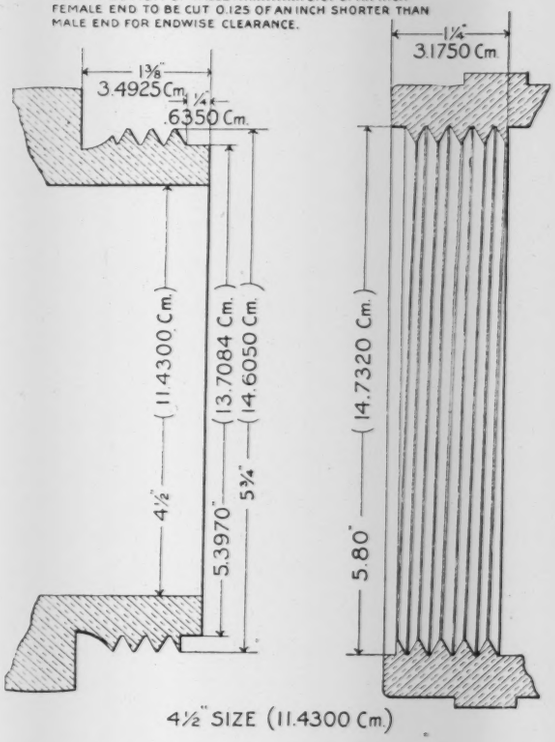

FIG. 4 DETAILS OF 4½-IN. COUPLING

NECROLOGY

CHARLES H. CORBETT

Charles H. Corbett was born in Buffalo, N. Y., on March 19, 1842, and was educated in the schools of that city. In 1858 he entered the employ of the Rogers Locomotive Works, Paterson, N. J., as an apprentice. His work was in the shop and drawing room, and during the latter part of the construction of the U. S. iron clad steamer Keokuk he was employed as assistant superintendent. In 1863 he identified himself with the Continental Iron Works of Brooklyn, of which he was a vice-president at the time of his death on January 14, 1914, working up from the position of draftsman to chief draftsman. He had a prominent part in the plans for the construction of various gas works throughout the East, notably at Boston, Worcester, Salem, Mass., Providence, R. I., and the various gas works of New York now merged in the Consolidated Gas Company. When the Continental Works was incorporated in 1887 he was made second vice-president.

He served the Society as Manager from 1901 to 1904.

DAVID N. MELVIN

David N. Melvin, for forty years superintendent and general manager of the American Linoleum Manufacturing Company of Staten Island, died in Miami, Florida, on January 27, 1914. He was born in Glasgow, Scotland, on July 21, 1840, and was graduated from the Andersonian University of Glasgow in 1860. For several years he was employed by Crawhall & Campbell, as engineer and draftsman, and later designed fireproof buildings and machinery for sugar refining mills in Scotland, Cuba and the West Indies. He afterwards purchased an interest in a paper mill near Oxford, England, which he operated until the abolition of the British tariff on paper made the business unprofitable.

Shortly after his arrival in America in 1867 he obtained a patent for an improved sectional safety steam boiler and later an automatic furnace door and a high-pressure engine. He also formed a connection with T. A. Weston of Buffalo, inventor of the differential chain pulley, and subsequently engaged in the erection of large buildings in the Michigan lumber region. In 1873 he became associated with Frederick Walton, the inventor of linoleum, and erected an extensive plant at Long Neck, S. I., which has grown to be one of the largest of its kind. In 1888 when the Walton patents expired, Mr. Melvin invented what is known as inlaid linoleum, and later wood inlaid, which have since been extensively manufactured under his patents.

Mr. Melvin was a member of the American Society of Civil Engineers and of the Richmond County Automobile Society.

WALTER AMBROSE PEARSON

Walter Ambrose Pearson was born in Putnam, Conn., on July 3, 1869, and died in New York on January 25, 1914. He was educated at Tufts College, Mass., where he was graduated in 1890 with the degree of B.A. Immediately afterward he entered the employ of the West End Street Railway Company of Boston, which was then going through the early stages of electric railway development. Mr. Pearson was employed first as a station operator.

In 1893 Mr. Pearson went to Brooklyn, N. Y., to take charge of the electric installation of the Brooklyn Heights Railroad Company, as electrical engineer, and in 1896 undertook similar work for the Metropolitan Street Railway Company of New York. Here he was active in the development of the Lenox Avenue underground electric system, the first to be developed in this country. In 1906 he went to Niagara Falls for the Electric Development Company of Ontario, in charge of the electrical installation and construction of this company's power house at Niagara Falls.

In 1910 Mr. Pearson went to Rio de Janeiro, Brazil, remaining for two years as assistant general manager of the Rio de Janeiro Tramway, Light and Power Company. Poor health due to climatic conditions forced his return and he became associated with the banking house of Bertron, Griscom and Company as consulting engineer, with which he was connected at the time of his death.

He was a member of the American Institute of Electrical Engineers, the New York Railroad Club, and the Engineers Club of New York, and was prominent in Masonic circles.

FRANKLIN PHILLIPS

Franklin Phillips, president of Hewes and Phillips Iron Works of Newark, N. J., died in that city on February 9, 1914, after a brief illness. He was born in Newark in 1857 and was a son of John M. Phillips, founder of the Hewes and Phillips company.

He was educated in the public schools and at Stevens Institute of Technology and Cornell University, graduating from the last in 1878, and immediately entering his father's firm, in which he was active up to the time of his death.

Mr. Phillips had a broad reputation as a steam and hydraulic engineer and was frequently called into consultation by eminent engineers in relation to large engineering projects. He was president of the New Jersey Foundrymen's Association and was actively interested in all civic movements that had for their object the prosperity and upbuilding of his city and state. He was a member of the Newark Board of Trade and of the Essex Club and was quartermaster sergeant of the Essex Cavalry Troop and had been major and inspector of small arms of the New Jersey Second Regiment of Infantry.

GEORGE C. SCHOFF

George C. Schoff was born in Annapolis, Md., on September 28, 1867, and was educated at St. Johns College and at the University of Arkansas, Fayetteville, from which he received the degree of C.E in 1889. After his graduation he remained at this institution as an instructor and assistant professor for several years.

In 1893 he became associated with J. M. Witham of Philadelphia, consulting engineer, as first assistant, resigning in 1895 to enter the Philadelphia sales office of the Babcock and Wilcox Company, where he remained until the time of his death, January 21, 1914. He represented the company in the design of a number of large power plants throughout eastern Pennsylvania, Maryland and Virginia.

Mr. Schoff was a member of the Union League Club of Philadelphia.

ARTHUR PIERCE TRUETTE

Arthur Pierce Truette was born in Boston, Mass., December 28, 1888, and died in Brookline, Mass., on December

17, 1913. He was educated in the Allston Grammar School of Boston and at the Brookline High School, and was graduated from the Massachusetts Institute of Technology in 1910. He acted as assistant at the Institute for one year and in August 1911 entered the service of the Goodyear Tire and Rubber Company, of Akron, Ohio, as power plant engineer, remaining with them until shortly before the time of his death. During his brief connection he reorganized and doubled the capacity of the company's power plant.

Mr. Truette was a member of the University Club, the Goodyear Technology Club and the Chamber of Commerce of Akron, the Northern Ohio Technology Club, the New York Technology Club, and the Appalachian Mountain Club of Boston.

MEETINGS

MEETINGS IN MINNESOTA

A meeting of the members of the Society was held in St. Paul on January 7, and was made the occasion of a lecture on the American Railroad Ditcher, by Oliver Crosby. The lecture was illustrated by moving pictures and proved most profitable and entertaining.

On February 11 there was a meeting of the Minnesota members in Minneapolis, a talk being given by C. L. Pillsbury on the Construction and Mechanical Details of the Minnesota State Prison at Stillwater. This was illustrated by numerous lantern slides. A discussion followed and Prof. Wm. H. Kavanaugh of the University of Minnesota, who was in charge of the 48-hour test, gave an interesting report with reference to the economy of this plan.

CHICAGO MEETING, JANUARY 28

A meeting of the Chicago Section was held in the Hotel Sherman on January 28. W. F. M. Goss, Past-President of the Society, welcomed the members and guests, and a paper on Boiler Tests with Illinois Coal, the Taylor Stoker and Four-Pass Edge Moor Boiler being employed, was presented by Bryant Bannister of Kewanee, Ill. Prof. G. A. Goodenough, Jos. Harrington, J. B. Brydon, R. H. Kuss, T. A. Marsh, A. Bement, J. C. Bannister, P. A. Poppenhauser and F. C. Gasche participated in the discussion. An abstract of the paper and discussion will appear in a later issue of The Journal.

A banquet preceded the meeting at which there was an attendance of 140.

BOSTON, FEBRUARY 4

A joint meeting was held at Boston in February by the Society in conjunction with the Boston Society of Civil Engineers and the American Institute of Electrical Engineers, the meeting being devoted to the general topic of Recent Developments and Present Tendencies in Railroad Work. Three papers were presented, one devoted to Rolling Stock, by Henry Bartlett, general mechanical superintendent of the Boston & Maine Railroad; another on Electrical Equipment, by Frederic D. Hall, electrical engineer of the Boston & Maine Railroad; and a third on Permanent Way, by A. B. Corthell, chief engineer of the Boston & Maine Railroad.

Mr. Bartlett, in the opening paper, confined his remarks principally to the development in locomotives in their relation to the greatly increased weights of trains and service requirements. He traced the development of the locomotive from the light eight and ten-wheel locomotives of 20 years ago to the powerful and efficient locomotives of to-day with superheaters, piston valves, Walschaert valve gear and many other refinements. He pointed out the interesting fact that the proportionate increases in power and weight of locomotives have been an important advantage rather than otherwise, in that with the increased weight has come provisions for more ample heating surface and larger grate areas, enabling the locomotive to deliver its rated tractive power with the consumption of less fuel. Reference was made to the tendency in freight haulage toward the use of articulated compound locomotives, and recent tests were quoted which show marked economies resulting from such practice. One of the most interesting features of the paper was the reference to the recent tests by the Pennsylvania Railroad at its Altoona testing plant of Pacific type locomotives, which showed the remarkable result of a horsepower-hour delivered upon 16.4 lb. of water and 2.66 lb. of coal; this has established a record and is of interest in contrast to the best record of 20 years ago, namely, 27 lb. of water and 4 lb. of coal per h.p-hr.

Mr. Hall, in discussing electric equipment problems, expressed disappointment at the slow growth of heavy electric traction and attempted to trace some of the reasons therefor. He pointed out that with present developments and improvements in steam locomotive operation, the electrical system of operation has little to offer from the standpoint of economy; it must therefore come from other reasons of advantage, such as more satisfactory or more reliable operation. The development of heavy electric traction was shown to be considerably hampered by the great diversity of opinion among engineers as to the most desirable method of electrical operation, the voltage to be used, or some of the other important factors in connection therewith. He suggested the advisability of some concerted action in regard to standardization of these elements, possibly in conjunction with the American Railway Association.

Mr. Corthell discussed extensively the general subject of track and track work, starting with historical development and the tracing constructional and detail changes up to modern practice. He devoted much thought to rail design, referring to the adoption of standards by the American Society of Civil Engineers and the American Railway Association. Some experiments upon so-called frictionless rails were reported and the effect of wear on them in curves noted. The paper treated also of rail joint fastenings rather completely and also the subject of tie-plates was discussed, in its relation to tie preservation.

ST. LOUIS MEETING, FEBRUARY 4

At a meeting of the Associated Engineering Societies of St. Louis at the Engineers Club on February 4, J. Irvine Lyle, manager of the Carrier Air Conditioning Company of America gave an interesting lecture on Air Conditioning. The paper was discussed by R. H. Tait, Edw. Smith, John Hunter, Hans Toensfeldt, H. H. Humphrey, E. H. Ohle, and L. C. Nordmeyer.

PHILADELPHIA MEETING, FEBRUARY 9

The members of the Society in Philadelphia held a joint meeting on the evening of February 9 with the American Institute of Electric Engineers at the Engineers Club. A din-

ner preceded the professional program at which there was a large attendance.

The subject for the evening was Business Training for the Engineer, the speakers being Dr. Alexander C. Humphreys, Past-President of the Society and President of Stevens Institute of Technology, who emphasized in his remarks the necessity for familiarity on the part of the engineer with business methods, including accountancy. At Stevens, he said, every student was obliged to take a course in the business features of engineering practice, and many, who did so under protest, were afterwards willing to acknowledge the valuable aid it had been to them. Dr. Humphreys was followed by Theodore L. Jones of the Edison Illuminating Company of Brooklyn, who spoke extemporaneously.

The speakers' remarks were discussed by H. H. Norris, Walton Clark, Henry Hess, C. H. Bigelow, G. A. Hoadley, H. V. Schreiber, C. V. Wein, W. C. L. Eglin, M. N. Miller.

CINCINNATI MEETING, FEBRUARY 12

A joint meeting of the Cincinnati Section and of the Engineers Club was held on the evening of February 12. J. Irvine Lyle, manager of the Carrier Air Conditioning Company of America, gave an address on Air Conditioning in which he mentioned the great influence of atmospheric conditions upon the quality and quantity of the product in textile mills, soap factories, bakeries, printing, lithographic and other industrial plants. Many instances were cited in which artificial changes of temperature and particularly of humidity had produced a direct saving in costs and greatly increased the output, the reasons for the improvement being given in each case. Mr. Lyle reviewed briefly the theory of air conditioning and explained the use of psychrometric charts in this connection. He gave illustrations of the saving of delicate fabrics in large stores by the elimination of dirt from the air sent into the buildings for ventilation, the reduction of temperatures by the introduction of humidified air and the limits of the reduction of temperature possible by this means being illustrated by calculation. Various washers and automatic humidifying devices were shown and their uses illustrated.

A large number of lantern slides and some apparatus were used to illustrate the lecture, and a general discussion followed. About 100 attended the meeting, which was followed by a lunch.

NEW YORK, FEBRUARY 10

An interesting meeting of the Society was held in New York on February 10, under the joint auspices of the New York Committee on Meetings and the Sub-Committee on Railroads. The paper of the evening, Brake Performance on Modern Steam Railroad Passenger Trains, was delivered by S. W. Dudley, assistant chief engineer of the Westinghouse Air Brake Company, Pittsburgh, Pa. The data presented are the result of an important series of tests made by the Pennsylvania Railroad in conjunction with the Westinghouse Air Brake Company, which were carried on for a number of months during 1913 with a heavy steel car passenger train and 40 observers, to determine many points of importance in the safe handling of heavy trains.

The tests were divided with a view to investigation of the five important factors in train braking separately, as follows: (*a*) The air brake mechanism proper, (*b*) the foundation brake rigging and percentage of braking power that can be adopted, (*c*) the method of application of the brakes, (*d*) the behavior of the brake shoes, and (*e*) the coefficient of friction between the wheel and rail. Under (*a*), the performance of the new type VC air brake system with electro-pneumatic control was compared in all details with the present commonly used type PM high-speed brake equipment, and the advantages of the improved system studied. The percentage of braking power, (*b*), was studied in its relation to the more efficient action of the improved brake system, with a view to considerable increase and very material benefits were thereby derived. The investigation of the method of application of the brakes, (*c*), was a comparison of the present single shoe method with the clasp-shoe method of brake rigging (two shoes per wheel) from which such important advantages are derived. The study of the behavior of brake shoes, (*d*), forms one of the most important laboratory investigations of brake shoes ever attempted, and brought out much information of value. The study of rail friction, (*e*), was to determine the limitations imposed by rail conditions upon braking practice and developed many new ideas. The paper as a whole created unusual interest and elicited a spirited discussion, which centered mainly around the new electro-pneumatic brake system.

SAN FRANCISCO MEETING, FEBRUARY 10

A meeting of the San Francisco Section was held in the rooms of the Engineers Club of San Francisco on February 10, the topic of the evening being the Transportation of Crude Oil in Pipe Lines.

E. I. Dyer, engineer-in-chief for the Union Oil Company of California, led the discussion by reading a paper prepared with special reference to experimental work on one of the oil pipe lines of his company, to determine the various factors influencing the loss due to friction in pumping oil through pipe lines, and the derivation of formulae by which the friction losses could be calculated. Mr. Dyer demonstrated his results by a series of curves plotted from a large number of field observations and combined all of the variable factors in one, which he has termed the viscosity coefficient. This viscosity coefficient takes into consideration also the element of time, which is an important factor in giving the change in the viscosity of the oil as it cools or is heated.

He was followed by Wynn Meredith, Mem.Am.Soc.M.E., H. W. Crozier, engineer for Sanderson and Porter, A. C. McLaughlin, superintendent of operation for the Kern Trading and Oil Company, E. T. Morris, manager of the Associated Pipe Line Company, and A. F. L. Bell, chief engineer for the Associated Oil Company.

H. T. Cory called attention to the confusion due to the many different standards in vogue in the oil fields, with special reference to the characteristics of the various types of oils. Robert Sibley, A. M. Hunt, and W. F. Durand were appointed a committee to investigate the matter and report to the Society such recommendations as in their opinion should be carried out to correct this condition.

About 80 were in attendance, among them members of the Student Branch of the University of California.

EFFICIENCY OF ROPE DRIVING AS A MEANS OF POWER TRANSMISSION

BY E. H. AHARA, MISHAWAKA, IND.

Member of the Society

THIS paper deals with a series of tests on transmission of power by rope drives under various conditions. The efficiency is measured under full, three-quarters, one-half and one-quarter loads. One inch best manila rope was used. The test covers drives of from one to eight ropes, with centers from 25 to 150 ft., on both American and English systems. Tests also covered open or straight drives, as well as indirect, or up and over drives.

It was stated that the importance of the tests may be estimated from the conclusions deducible from the data obtained. They seem to show that the efficiency in rope driving is considerably greater at the lower speeds than at the higher ones, the dropping off being especially noticeable above 4500 ft. per min. of rope speed. They also show that the efficiency of a rope drive is not materially affected by distances between centers up to 150 ft., that the drop of efficiency at 50 per cent load is comparatively small over that of full load, and that if proper care is exercised to have all grooves perfect in pitch diameter many as well as few ropes can be run on a drive with good efficiency. With the American system, increasing the slack rope tension up to 360 lb. in a 1-in. rope does not appear to decrease its efficiency, but rather to increase it if power is used in conformity with this tension; but only such tension should be used as is necessary to drive the load needed. For the rope tested the American system has very much more capacity than the English system, and has also a higher percentage of efficiency. In general it would appear that, where there is a considerable power to be transmitted, the properly worked out rope drive gives a most efficient and economical method, and where conditions are favorable to its installation no other known method of transmission will so well conserve power losses.

FIG. 1 ARRANGEMENT OF APPARATUS FOR TESTING ROPE DRIVES, SHOWING AN AMERICAN OPEN DRIVE, 50 FT. ON CENTERS, SEVEN ROPES, 4500 FT. PER MIN., 155 H.P.

The efficiency as determined includes the losses in the rope itself, the friction in the bearings on the driven shaft, and the losses due to the inertia of the driven wheel and the prony-brake wheel, and, also, in the American system the friction of the tension equipment. All tests were made to include the friction of the receiving shaft and bearings as it was thought this would more nearly approximate working conditions and make the data obtained of more general application in ordinary comparisons. All bearings used were of the ring oiling babbitted type, and the ropes were all 1-in. ma-

Abstract of Paper. Published in complete form in the August 1913 issue of The Journal of The American Society of Mechanical Engineers, and presented at the Annual Meeting, December 1913. Pamphlet copies may be obtained: price, 10 cents to members and 20 cents to non-members.

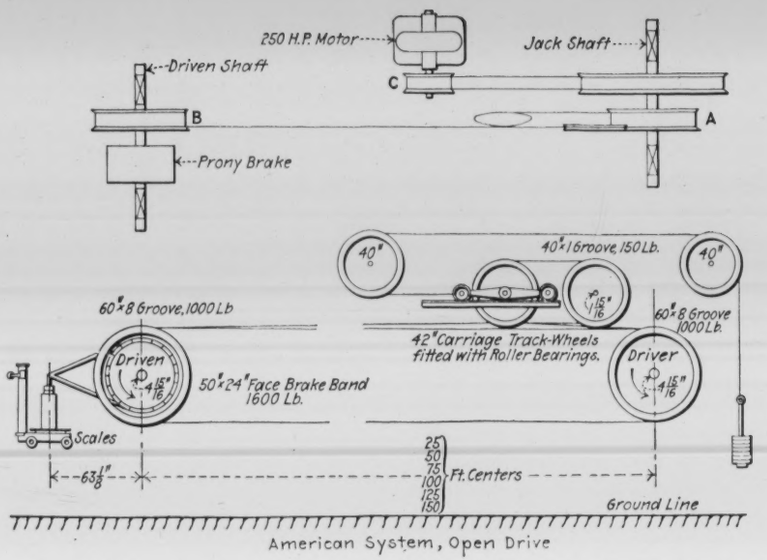

FIG. 2 GENERAL PLAN OF AMERICAN OPEN, OR STRAIGHT, DRIVE SYSTEM

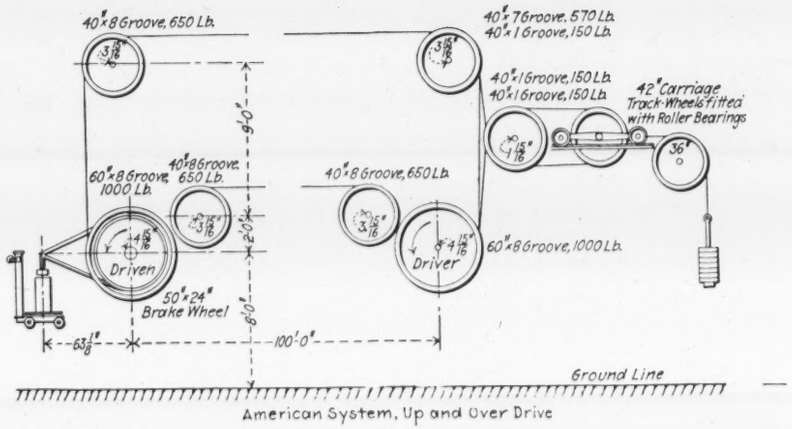

FIG. 3 GENERAL PLAN OF AMERICAN "UP AND OVER," OR INDIRECT, DRIVE SYSTEM

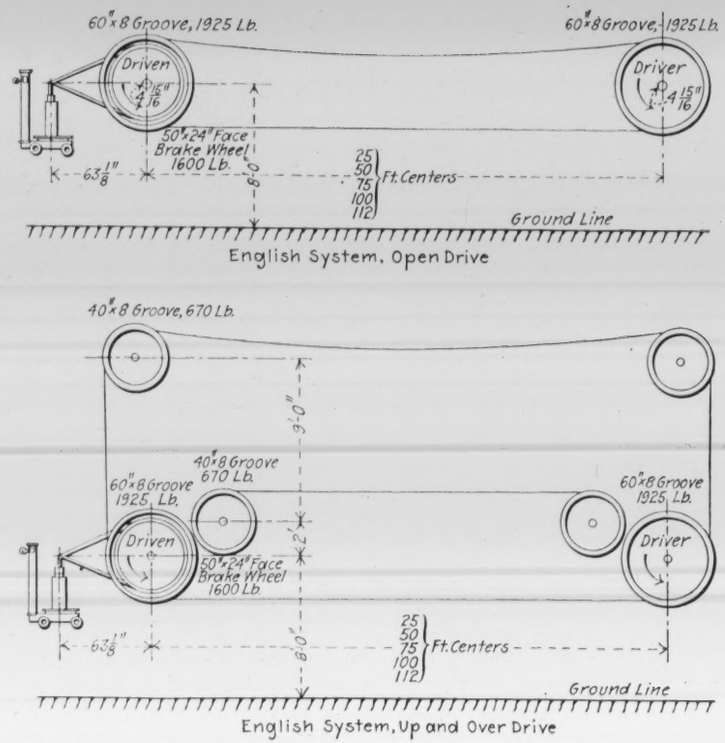

FIG. 4 PLAN OF ENGLISH OPEN DRIVE AND "UP AND OVER" DRIVE SYSTEMS

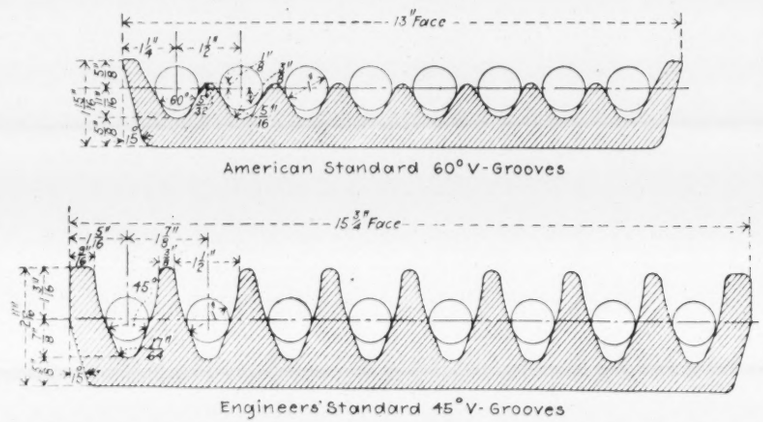

FIG. 5 DETAILS OF GROOVES USED ON DRIVER AND DRIVEN WHEELS

nila rope of best quality, carefully treated with a rope dressing to prevent the entrance of moisture and to keep the surface in as nearly uniform condition as possible. It was found during the test that this was of great importance as very slight changes in the rope surface immediately affected its capacity and efficiency.

With the American system a lower efficiency is shown on the lower number of ropes. This is undoubtedly caused by the fact that the eight-grooved wheel made for testing eight ropes was used for all the lesser number of ropes to avoid the expense of making additional wheels with a suitable number of grooves for each drive. This together with the weight of the prony brake increased the proportional friction on the smaller loads, and is, therefore, a larger percentage of the total load in the drive of few ropes. With the friction of driven shaft eliminated, limiting the losses to those in the rope alone, it is believed the efficiency in a single rope would be as great if not greater than any multiple thereof.

In all of the above tests the tension in the slack side of the rope was kept as uniform as possible at 180 lb. by means of weighting the tension carriage properly. In order to ascertain what tension would give the greatest degree of efficiency, irrespective of life of rope or wearing qualities, a test was made with the slack rope under varying tensions. This is determined on one rope because the capacity of the single rope was, under the heavy tension, as great as that of the motor, so no proper comparison could be obtained on more than one rope.

One of the greatest troubles in rope driving, when installed by inexperienced engineers, has been the lack of uniformity in pitch of the grooves where many ropes were used. This differential in the grooves compels slippage of the ropes which not only causes loss of power, but also rapidly depreciates the rope, and often causes the rope to flop around badly. To test the loss of efficiency in this case two wheels 60 in. in diameter, of eight grooves each, were made up exactly alike so far as could be, and after most careful measurements the grooves on either wheel were found not to differ more than 1/64 in. in circumference from any other on the same sheave, and a test made. The driver was then removed, and the pitch diameter of each groove made approximately 1/32 in. less than the preceding groove so the eighth groove was ¼ in. less in diameter than the first one. Again it was placed on the driving shaft and a duplicate set of tests made. In this test as the first groove was ¼ in. larger in pitch diameter than the eighth groove, with the sheave revolving at 160 r.p.m., there would necessarily be a slippage in an inelastic band of over ten feet per minute. The photographs taken of this differential drive, shown in the August 1913 issue, are quite illuminating, as they show plainly the sag of the various ropes under this condition, and how under heavy load they stretch and slip on the grooves of the sheave. The elasticity of the rope in this case undoubtedly lends itself to aid efficient operation.

The "up and over" American drive was tested because it is typical of all but direct drives, i. e., straight from driver to driven, and the difference in efficiency between this type and the open drive will serve as a basis of comparison where but two additional right-angle turns are introduced requiring four additional idlers. This test was run on approximately 100 ft. centers with a new rope, the same rope being afterwards used in the testing of the various English drives.

In testing the English drives, that proper comparisons might be made, the ropes were all cut to the same measured length, and the splices carefully made, so that all ropes might be equally tight when applied to the sheaves. The movable tower was then carefully moved back, the rope being run slowly meanwhile until the sag in the rope was approximately the same as in the American drive of the same center distance in which the slack rope was under a tension of 180 lb. This is undoubtedly a higher tension than is used in general practice on the English drive system with this size of rope, and the capacities and efficiencies shown are perhaps higher than are ordinarily attained in common practice. The efficiencies, when compared by speeds, of the English open drive, show a marked decrease as the speed of the rope increases, falling as low as 84.5 per cent at 5500 ft. rope speed.

The general tendency in all tests made, both English and American, was corroborative of this tendency toward decrease in efficiency as the speed of the rope increases. There was, however, a lack of smoothness to many of the curves owing, it was thought, to variations in rope tension, and perhaps slight changes in the surface of the rope due to climatic changes. This was very much more noticeable on the English than on the American system, the irregularity of the curve on the former being affected by the fact that a greater load was sometimes attained on a certain speed than could later be reached on the next higher speed.

The efficiency of the English drive, within the limit of distances tested, remains practically constant irrespective of center distance; while with reference to number of ropes, it increases as does the American for the first few ropes, and then remains practically constant through the additional ones.

In order to test the effect of tension on the English system a comparison was made by moving the receiving tower forward 1¼ ft. after making a series of tests, and then making another corresponding series. When sheaves with proper English pinch grooves, as shown in Fig. 5, were used there was no appreciable difference either in power transmitted or in efficiency. Greater variations than 1¼ ft. in center distances could not be satisfactorily tried because of the slack ropes dragging on the ground.

A new rope was used on the American open drive, another new one being started with the American "up and over," which latter was also used on both the English drives. The time of introducing the new rope is mentioned because it was found that a new rope had very much less capacity, owing to its low coefficient of friction, than the same one had after it had run a short time in work, and having less capacity it would usually have less efficiency also. The stiffness of the rope when it was new also seemed to add friction to the drive owing to the bending action in passing around the sheaves, which on the test were only 60 in. in diameter. With larger main drive wheels, where the rope is not bent to so small a radius, the efficiency would undoubtedly be slightly increased over the results here shown.

The capacities of rope drives are affected by so many variables that no particular attempt is here made to state capacity other than in general figures, obtained as indicated in the early part of this paper, and used merely to have a uniform method of taking the tests. In the original paper in the August 1913 issue some limiting capacities obtained in the open drives, and in the "up and over" drives, are presented in curves. These limiting capacities shown are in no sense to be considered as available working capacities, but merely as limits reached in driving capacities, the general tendency of the whole series being used to form a decision, rather than any one curve, the practical working capacity being much lower than the limits shown. It is to be regretted that the power available was not great enough to get the larger capacities as so few points were obtainable on the American open system. Even at the low speed of 2500 ft. four ropes could not be made to slip with the 250 h.p. available.

The irregularities of these limiting horsepower capacities are caused by many variables, some of which are weather, surface conditions of rope, condition of rope wheel grooves, etc. In connection with the groove in the wheel it was found that if a rope began to slip in a groove and warmed it up slightly the coefficient of friction seemed to decrease very rapidly, and if a limiting test were made under these conditions it was invariably much lower than if it were taken just before the rope started to slip. As each test had to be taken in its scheduled order some of those shown were taken at intervals of several weeks.

As the limiting capacities of the English drive are very much lower than the American, it is thought the efficiency is likewise affected, the friction in the former case being a much larger proportion of the power delivered. And again, the English system in order to get driving power in the rope, pinches it in the narrow groove requiring considerable force to withdraw it again. This effort being exerted continuously uses up considerable power. The American system, on the contrary, uses a 60-deg. groove in which the rope lies freely and withdraws without effort.

DISCUSSION

Henry G. Stott said that the question of efficiency was, of course, a very important one, but there was also another involved, the question of reliability. He had had a good deal of experience in driving high-speed machines with rope drive on the European side of the Atlantic, where both systems were used. While the American system of continuous rope was a good deal easier to operate, yet in the case of an accident to the rope, the entire rope became tangled up and something else was broken; whereas with the English system of separate drives, there was a number of ropes, each one separate, and if one rope broke the work was not interrupted, so that the question of reliability should also be taken into consideration.

Geo. N. Van Derhoef (written). Why does the efficiency decrease as the speed increases, in both the American and English systems? In the American system the slack side tension at any speed is equal to one-half the pull of the carriage plus the centrifugal force due to the speed; while the slack side tension in the English system is due to the initial tension less the centrifugal tension, and less a decrease in tension due to the total elongation of the rope band due to its elasticity. Is this due to "skin friction" of the rope sliding through the air, or to bending and unbending of the rope (either or both of which would indicate a functional loss due to speed), or on the other hand, is it caused by a change in the coefficient of friction of the bearings, which would indicate that the loss was entirely outside of the rope and that a high-speed rope may be as efficient as a low-speed one. This is quite an important point because in the design of many large drives the speed or travel of the rope can be made almost anything desired.

The tests showing the results for different distances between centers would seem to eliminate the "skin friction" idea, because the difference in the total length of rope is sufficiently marked to make any loss of this kind of any amount quite perceptible. In the English system test, the slight downward tendency to the average line is not sufficiently marked from which to draw any conclusion.

The tests showing that with the American system the efficiency at half load is practically the same as at full load, indicates that a drive may be designed to take care of occasional peak loads without a sacrifice in efficiency when operating at the average normal load we usually get in practice; or, to put it another way, without loss in efficiency when meeting a peak load, which, although generally of momentary duration, may at times be prolonged over considerable periods. If this is functionally true of American system rope drives in general, it is a most important characteristic.

The tests covering the efficiency with different numbers of ropes with drives of both systems show two important things: (*a*) that it is of basic importance that the sheaves be accurately grooved; and (*b*) that with properly grooved sheaves, drives for large powers, where many wraps of rope must be used, will not apparently be accompanied with any loss in efficiency. This seems to be quite different from what we find with large belt drives where the crowning of the pulleys gives an inherent loss that cannot be entirely prevented. A corollary from the above is that the choice between a few ropes of large diameter and a good many ropes of small diameter is not dependent upon the question of efficiency but on other design factors.

The fact that increasing the slack side tension up to at least 360 lb. for a 1-in. rope increases rather than decreases the efficiency is important to both the designer and user. No doubt the life of a transmission rope depends very largely on the load factor. Still, it is often necessary to increase materially the load on any transmission due to changes in operation, emergency, etc., far beyond that contemplated in the design. That this can be done with the American system simply by increasing the tension weight and at no greater penalty than a more or less proportionate decrease in the life of the rope means great flexibility and certainty in getting out production.

That the efficiency of the so-called up and over drive is less than the direct is only what might be expected from the greater number of parts. That this seems to be rather less marked in the American than the English system is in line with the results shown by all the various tests.

That the coefficient of friction of a new rope is less than that of a conditioned one is well known. In the design of an English system drive great care must be exercised to have the drive amply large to transmit the power desired when the rope is new, otherwise full operation cannot be secured until the ropes have been conditioned. In designing the American system it is not necessary to give any attention to the coefficient of friction of a new rope at all. The design should be based on the actual normal running condition. All that is necessary to do when a new rope is put on the drive is to use the proper amount of tension weight to give the desired traction and to reduce same just as rapidly as the rope becomes conditioned and the coefficient of friction rises to the normal point.

To secure all the advantages that are possible with the American system drive the driving and driven shafts should be of ample size so that extra tension weight can be used whenever desired, otherwise the great flexibility of this system would be unavailable on account of a detail that should have attention at the time of designing.

W. H. Kenerson asked whether the result, outlined in one of the curves, showing that the efficiency dropped with increase in speed, was derived from the four individual observations, or whether the points were the average of a large number. If, as the author further showed in another curve, the distance between centers did not affect the efficiency, or in other words, the line drawn through those five points was a straight line horizontally, it would be seen that if those were individual results only, it could be just as fairly deduced from the first curve that the line was horizontal; in other words, the variations due to other causes, possibly, would be as much as 4 per cent, as indicated.

Selby Haar (written). Having had occasion to estimate the losses of power in rope transmission, I can cordially endorse Mr. Ahara's opening statement. It is difficult enough to find reports of actual tests relating to the efficiency of belt drives, but there is even less in print about efficiencies of rope drive. It was in the course of a search for such data that some investigations were discovered which form the basis of a paper[1] presented at the December meeting of the Society in 1910. These tests included a large number on rope transmission for which the efficiency was carefully determined.

The description of the testing machine of that paper may be summarized here in the statement that the machine is horizontal, very compact because both driving and driven shafts are located in the measuring and straining heads respectively, and electric motors for supplying and absorbing energy are mounted directly on the shafts. The sheaves were specially designed for these tests, had diameters 2500 mm. (98.5 in.), 1500 mm. (59 in.) and 1040 mm. (41 in.), with 45 deg. V-grooves. Pains were taken to have all grooves nearly the same diameter. Most of the tests were conducted on a round manila three-strand rope 50 mm. (2 in.) diameter, 20.5 m. (67 ft.) long, the rest being taken with six-strand, so-called trapezoidal rope, with a sectional area approximately equal to that of the round rope. The majority of observations was made on transmission on the English system; the arrangement with endless rope was probably not entirely representative of the American system, the automatic adjustment of the tension in the rope being lacking.

The readings for a test included volts and amperes for power both supplied and delivered, rope-speed, rope-pull and revolutions. In order to determine the efficiency, however, only the electrical readings are required. All electrical, bearing friction, and windage losses of the testing machine were determined and allowed for so that the efficiencies reported apply to the rope only.

Upon this basis the English system showed higher efficiency than the American. All test results are reported in the form of curve-sheets, the efficiency curves of single tests being superposed, and, so to speak, enveloping curves constructed from them, from which the upper and lower limiting efficiencies at any given load or speed may be taken. On the English system with a 2-in. round rope, the highest efficiency reported is 0.89 to 0.945 at 38 kg. (84 lb.) effective pull per rope for four ropes, and 0.945 to 0.97 at 100 kg. (220 lb.) for a single rope. Pulleys of like diameters were used, while the distance between centers was about 6 m. (20 ft.). The tight part of the ropes was on the bottom. It was also observed that the use of driving sheaves smaller than the driven ones did not affect the efficiency, but when the larger sheave drove, the efficiency was reduced. Furthermore, the efficiency decreases with increasing speed, one set of values being 0.95 at 13 m. per sec. (2550 ft. per min.), 0.925 at 30 m. per sec. (5900 ft. per min.) and 0.90 at 39 m. per sec. (7700 ft. per min.). With an endless rope (American system) maximum efficiencies as follows were reported: 0.86 to 0.895 at 55 kg. (121 lb.) effective pull per rope. A particular value with three wraps of rope on pulleys 5933 mm. (19.5 ft.) apart, 1040 mm. (41 in.) (driver) and 2500 mm. (98.5 in.) (driven) at a rope speed of 26 m. per sec. (5100 ft. per min.) is a maximum efficiency of 0.89 at the effective pull 50 kg. (110 lb.) per rope. Practically equal values were obtained (also equal carrying capacities) whether the tight part of the rope was on top or bottom. The initial rope tension was also reported, the most favorable value for the 2-in. rope from the standpoint of efficiency and smooth running being about 150 kg. (330 lb.). Other interesting observations are the recommendation of a maximum rope speed of approximately 25 m. per sec. (5000 ft. per min.) and the confirmation of the prevalent

[1] A New Theory of Belt Driving, The Journal, Am. Soc. M. E., December, 1910.

opinion that with constant initial tension and rope speed the efficiency increases with the sheave diameter.

Although no figures relating to the trapezoidal rope are given, it is reported that its efficiency is lower than that of the round rope.

The formulae for calculation of efficiency developed in the previous paper were applied to several of the observations reported in the paper, but with a disappointing result, because in all cases the observed losses were much greater than calculation, not taking into account windage losses of the driven sheave and brake pulley, indicated.

THE AUTHOR. Answering Mr. Stott's question as to reliability, there is very little liability of accident from rope drives if properly installed, and given even a fraction of the attention that other means of transmission require.

It is common practice by those most experienced in the installation of rope drives to safeguard them by placing what is called a tell-tale, an electrical device, below the rope where a bend is made around the sheave that will, in case the rope becomes stranded at all, make an electrical connection and either throw out a clutch stopping the drive entirely or ring a gong to notify the engineer so the rope may have immediate attention.

If a rope is properly inspected occasionally, should any distress appear, it will be observed and then can be repaired at night and never occasion any delay during working hours.

With either English or American methods the freedom from delays depends on the care in inspecting. There is but one rope to watch in the American system while there are many in the English. It is a common occurrence for American drives to run three or four years without touching the rope at all when properly installed.

Mr. Van Derhoef raises a hard question: Why is a rope more efficient at low than at high speeds? My tests have not gone far enough to determine these causes. All the tests made, however, covering this long period of time, indicated in every case that the higher the speed the lower was the efficiency. It would take a long series of tests to develop why this is, but there is no doubt of the fact.

If Mr. Kenerson will refer to the various curves presented in the paper, he will see the same general results as he refers to so far as the decrease of efficiency as the speed increases. This was a general fact shown by a great many tests, and is not depending on an isolated test (tests were not made below 2500 ft. rope travel per minute).

The higher efficiency at low speeds is probably not due entirely to one cause. Skin friction and rope elasticity are possibly factors. The power to drive the sheaves and bend the rope at the high speeds may be more, proportionately, than at the slower speeds.

In Mr. Haar's discussion there are several tests reported that would not be considered good practice in rope transmission work, and therefore have little actual bearing on the subject.

A 2-in. rope would not be effective on pulls of 84 lb. or even 220 lb. This would be especially true in the American system where 180 lb. in the slack side for a 1-in. rope is a common tension. The so-called American system without automatic tension adjustment is only a modification of the English system and would undoubtedly increase the friction, as it would add one sheave to the friction load without any compensating benefit. It is in no sense an American system drive, and would warrant no deductions for the American system.

It is difficult to understand why efficiencies should be lower with a large driver and a small driven sheave than with a small driver and a large driven sheave. The writer made no tests on this point, but was under the general impression there would be no difference until slipping took place, and that this would happen quicker with the small driver than vice versa.

Mr. Haar in applying his formulae to the paper perhaps did not take into account the fact that in these tests the friction of the driven end was included with the losses in the rope itself, thus making the efficiencies much lower than they would be in the rope alone, as is usually figured.

Courtesy of Tiffany & Co

GOLD MEDAL PRESENTED TO COL. G. W. GOETHALS, BY NATIONAL GEOGRAPHIC SOCIETY, AT WASHINGTON, D. C.
MARCH 3, 1914

"The magic of the engineer is that he can change the face of nature and show the work of his hands, and that it is in some deep sense creative in character."—(From Presentation Speech by President Wilson.)

FIRE PROTECTION SESSION

PAPERS CONTRIBUTED AT THE ANNUAL MEETING BY THE SUB-COMMITTEE ON FIRE PROTECTION

This meeting was a symposium on Fire Protection topics, supplementing a similar session at the spring meeting in Baltimore in 1913. The papers read at the Baltimore meeting were devoted to the larger aspects of the problem as related to building construction and conflagrations; while at this meeting engineering details having a bearing on fire fighting and fire protective methods were discussed. Five papers were presented: The Fire Hazard in Turbo-Generators, G. S. Lawler, Boston, Mass.; Extinguishing of Fires in Oils and Volatile Liquids, Ed. A. Barrier, Boston, Mass.; Control of Automatic Sprinkler Valves, Fred J. Miller, New York; The Need of More Care in the Design and Construction of Elevated Tanks, W. O. Teague, Boston, Mass., and Fire Pumps, by Ezra E. Clark, Boston, Mass.

THE FIRE HAZARD IN TURBO-GENERATORS

By G. S. Lawler,[1] Boston, Mass.

Non-Member

The chances of electric generators of the older types being seriously injured by fire in the event of some part of the insulation failing is slight. Occasionally arcing will ignite the insulation at some point, but it is seldom that the fire will spread much before it is extinguished. This freedom from fire damage is due principally to the comparatively low speeds, the accessibility of the combustible insulation, and the fact that the machines being of large mass per unit capacity, the insulation is considerably distributed.

This condition of practical freedom from fire is reversed in the case of generators of the turbo type, for when a short circuit occurs in one of them there is a great chance that the insulation will be ignited and the machine be badly damaged; in fact such damage has occurred in a number of instances.

The chief causes of the increased hazard in the more modern type generators are as follows:

a The volume occupied by this type of machine is very much less for the same capacity than that of the older types of generators, so that the combustible insulation is more concentrated and, therefore, much of it is exposed, even to a slight arc or fire. The covering on the conductors depends greatly for its insulating qualities on the presence of oils or gums of a highly combustible nature. The amount of this combustible insulation on the higher voltage generators is naturally greater than in the low voltage machines.

Owing to turbo-generators having only a few poles the end connections between slots form a large proportion of the total length of conductors, in fact in some designs approximately one-half of the coils are outside of the slots. These end connections, one-half being on one side of the machine and one-half on the other, are exposed to fire, and as with a pile of loosely laid sticks, fire will rapidly extend from the insulation on one coil to that on the others.

b Owing to these generators being of exceedingly large capacity in many instances, (one of 30,000 kva. capacity now being constructed) an enormous amount of energy is involved in a short circuit, especially at the instant the short occurs and as the arc is confined in the limited space with the combustible insulation, it would seem impossible for the insulation to escape being set on fire at many points simultaneously.

c The machines are cooled by forcing large quantities of air through the spaces between the conductors. The large and constantly renewed supply of oxygen will hasten combustion when it is once started. The air is given somewhat of a rotary motion by the rapidly revolving rotor which has the ventilating vanes on it and consequently fire when started will be quickly swept around the exposed insulation.

d The generators are totally encased with the exception of the air inlets and outlets and even these in some designs are under the machines. This construction prevents access to a fire and much valuable time will necessarily be consumed before extinguishing agents can be used effectively. When the field current is cut off, as is necessary in case of short circuit, the only means of bringing the rotor quickly to rest is lost and it will continue to run for a long time after the steam has been shut off. Some machines will run for over an hour. This continued rotation is not conducive to the quick extinguishing of fire, especially when the ventilating vanes are mounted on the rotor.

In addition to the possible causes of arcing existing in the case of the older types of generators, the turbo-generator is subject to momentary large current rush at instant of short circuit, even if the short is external

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Presented at the Annual Meeting, 1913, of The American Society of Mechanical Engineers.

to the machine itself, unless means are taken to keep the current within safe limits. The heavy rush of current causes mechanical stresses in the conductors, which in some cases are severe enough to distort the conductors, especially where outside the slots, and to injure the insulating covering, resulting in a short circuit within the generator itself. In some designs the internal reactance of the machines will permit of the momentary current rush amounting to 40, or possibly more, times the normal full-load current of the machines.

The possibility of the conductors being distorted has been reduced in some cases by designing generators with sufficient internal reactance, or by providing external reactance such that the current at the moment of short circuit will not be great enough to damage the generators. Attention has also been given to supporting the stator end connections to prevent their distortion. These means have undoubtedly greatly increased the safety of the turbo-type of generator from possibilities of internal short circuit, but in no way tend to prevent a fire resulting should an arc occur.

A short circuit in the rotor will probably not result in a severe fire unless under exceptional conditions. This is also true if the short circuit occurs inside of a stator slot. A short circuit involving a stator coil, however, is more apt to occur at the end of the slot where the conductors are exposed.

As asbestos is now used largely for insulating the rotor windings and as these windings are well protected, it is probable that only in cases of severe fire in a machine will the rotor windings be damaged to any extent.

While the generators may be free from fires during the earlier portions of their life owing to the proper use of reactances which prevent external troubles seriously affecting the machines, as they get older the ordinary causes of breakdown of insulation are liable to occur and fires result. Probably in most cases generators will not be discarded until some trouble, usually in the nature of a short circuit, has occurred at least once in each, so that it is reasonable to expect that unless further preventative means are taken, turbo-generators stand a good chance of serious damage by fire at some time during their life. Although many fires have occurred, probably most of them have happened during the generator development stage. Generators of the turbo type are of such recent production that none of them has yet reached a life which could be considered old and, therefore, the troubles which can be expected near the end of their life by fire have still to come.

Undoubtedly the manufacturing companies have given serious thought to the matter of the reduction of the fire hazard in turbo-generators and have employed all means practical at the present time to this end, but there is still very much to be desired. The following several means if taken together would seem to minimize the chances of a serious fire:

a If a suitable material could be found a non-combustible outer covering could be placed over the insulation on the stator end connections. This would greatly delay the spread of fire and even if no other protective means were taken, would undoubtedly prevent much serious damage. Where fire extinguishers were used the covering would at least hold back the fire until they could be brought into play. At present no material suitable for such a covering appears to be available.

b If a non-combustible outer covering should be put on, its advantages would be partially lost in time unless the cooling air were freed of the dirt and oily vapor liable to be in it. This could be done by filtering, as has already been advocated several times.

c Means could be provided for cutting off the air supply in case of fire in generators by placing dampers in the inlet ducts designed so as to be normally held open by fusible links. The links could be placed so that they would be quickly fused by the heat and allow the dampers to close automatically. By reducing the oxygen supply to that entering by leakage the action of the fire would be slow.

d Arrangements could be provided for the quick introduction of carbon dioxide gas into the machines. The carbon dioxide could be kept in liquid form and piped through valves, expansion tanks, etc., to the generators. The valves could be arranged to be opened by the closing of the air inlet dampers so that the gas would be automatically introduced into the generators. This gas would be very effective in extinguishing fires inside the machines after the air supply had been cut off.

The employment of some efficient method of reducing the fire hazard in generators of the turbo type either along the lines mentioned or in some other way is important. The value of these generators is great and the damage by fire may amount to a considerable proportion of the first cost. It is probable that the damage is more liable to occur towards the end of the life of the generators, but even then the loss may be large, both directly and indirectly. The large central stations have reserve units so that the increased damage due to fire in one of their generators would probably not affect the continuity of service, but the increased time necessary for repairs may be long and during this time the reserve capacity will be weakened. In the case of industrial plants the longer time needed for repairs might be serious. Many manufacturing concerns who generate their own current depend on only one unit and, therefore, their whole production, or a large part of it, would be affected.

DISCUSSION

B. G. LAMME[1] (written). Having been connected with the turbo-generator business since its beginning in this country, I am naturally much interested in the conclusions drawn by Mr. Lawler. In general, his statements can be accepted, and about the only criticism which can be made is that he does not go far enough in some of his explanations and recommendations. The following may therefore be considered as a supplement rather than a criticism of Mr. Lawler's paper.

Two main facts stand out in connection with fire troubles in turbo-generators: namely, that the percentage of fires is greater in high capacity machines than in those of moderate or low capacity; and that fires are relatively much more frequent in high voltage machines than in those of low voltage.

As small capacity machines have been in use for a much longer period than those of large capacity, the latter being of comparatively recent date, it would appear that if age of the unit, or of the insulation, were of first importance in causing fires, there should be a preponderance of fires among the older and smaller units. But such does not appear to be the case, and apparently a principal cause must be looked for elsewhere. Presumably this lies in the greater energy liberated in the case of a short circuit, together with the vastly greater ventilation in the larger units.

If a short circuit occurs in a large unit, the electromotive force producing such short circuit cannot be reduced instantly by cutting off the excitation from the field, for it takes an appreciable time for the field magnetism to die down. This is especially the case in the large, solid rotors, which are now extensively used in such machines. Therefore, if a short circuit, resulting in an arc, is established, the energy expended may be enormous, as Mr. Lawler has pointed out, and, even if the field excitation is very quickly cut off, the expenditure of energy may still last for a period sufficient to establish a fire in the end windings. Apparently there is heat enough in such short circuits to "gasify" the insulating varnishes in the neighborhood of the arc, and if this condition is once started, it seems to spread rapidly.

A series of tests was made under my direction to determine whether an asbestos taping over the outside of the end windings would so delay the combustion that the fire might be extinguished without doing any great damage. However, these tests showed that when an arc is once started, sufficient to gasify the varnishes, the asbestos-covered coils burned about as quickly as the others. In fact, there was no encouragement whatever in our tests.

This does not mean, however, that some more effective protective covering may not be developed at some future time. Attention is called to the fact, however, that present available materials, such as asbestos tape, might ultimately represent more of a danger factor than a protection, as has already been referred to by Mr. Lawler. Some very costly experiences have been encountered by electrical manufacturers in the use of asbestos tape as an outside protecting covering in other than turbo-generator apparatus.

As to the second fact stated, that a far greater percentage of fires occurs in high voltage machines, this needs no particular amplification. While a low voltage machine might give as much energy on short circuit as the high voltage machine, yet such short circuits are less liable to happen inside the machine. Moreover, the low voltage machine has relatively less insulation on its end windings, and therefore there is less tendency to formation of combustible gases. Moreover, the majority of large capacity machines are wound for relatively high voltage, and, as stated before, the larger percentage of the fires occurs in the larger units. Thus the questions of capacity and voltage are so related that it is difficult to say whether either one is more responsible than the other for fire damage.

As to the effect of age on the fire risk, experience has not yet shown definitely that comparatively old machines are liable to suffer from a fire to any greater extent than new ones. This may be due to the fact that old, well baked and well dried insulations do not seem to be as readily combustible as new "green" insulations. The latter will probably generate gases more quickly than the thoroughly seasoned material. Therefore, as far as the insulating material itself is concerned, age should probably make the conditions no worse. However, accumulations of oil, dust and other foreign materials on the end windings, should make the conditions somewhat worse.

As to fire protection, Mr. Lawler's suggestions are to the point, and the remedies which he proposes should be effective to a certain extent. However, a number of things should be taken into consideration in this matter. He suggests, for instance, automatically cutting off the air supply by closing the inlet, and thus allowing only the leakage air to pass through the machine. This remedy should be fairly effective if the leakage can be made small enough. For instance, a 20,000-kw. turbo generator unit may have 50,000 to 75,000 cu. ft. of air per minute blown through it, in normal operation; this is vastly more than required to maintain combustion if a fire is once started. Even if the main inlet pipe is very completely closed, there might be a leakage of possibly 1 per cent through joints in the inlet valves, in the end housings of the machine, and at other points. This would mean 500 to 750 cu. ft. of air per minute through the machine, which would probably be ample to maintain a very damaging fire.

Furthermore, with even a relatively slight percentage of the normal quantity of air leaking into the machine, it is obvious that a small amount of carbonic dioxide gas would have but little effect. Therefore, the gas would have to be supplied either in great volume, or the air leakage must be made exceedingly small, in order that the gas may become effective. The problem is further complicated by the fact that, in some designs of machines, the chambers containing the end windings are normally under pressure which resists the flow of any extinguishing gases into such chamber, unless fed in at the ventilating fan or fans. In one case which I have in mind, where a fire occurred in the end winding, an attempt was made to introduce gas into the end housing, but without success, on account of the high internal pressure. The only effective extinguisher, in this particular case, was the use of a fire hose with the city water pressure behind it. This put out the fire, but the damage was almost as great as if no extinguisher had been used.

It should be remembered that the fumes from the fire are, in themselves, a good extinguisher, and therefore, if these fumes can be kept inside the machine, combustion will either be stopped or very much retarded. Therefore, one

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remedy which has been proposed at times is to not only close the inlet in case of fire, but also to close the outlets. This may be difficult to accomplish practically, but should be fairly effective.

In the usual turbo-generator, the ventilating fans form part of the unit itself, and the ventilating tendency or action is present until the machine is shut down. However, in some recent machines of very large capacity, separate blowers are provided, and where such is the case, some automatic means might be provided for shutting down the blower when a fire is started in the machine. In such an arrangement, the effect of leaks would be very much less pronounced than in machines with self-contained blowers. However, a note of warning should be sounded in connection with all automatic devices which affect or control the ventilation of large turbo-generators. I refer to the fact that such devices, if they act improperly, may cause the very trouble which they are intended to remedy. Large turbo-generator units are so dependent upon artificial ventilation that they may overheat very quickly, and thus cause a fire, in case the ventilation is accidentally shut off, even for a short time. Therefore, if the fusible links mentioned by Mr. Lawler should act, through some defect, to close the inlet passages, or cut off the normal ventilation, and this were not discovered quickly, overheating might result.

Obviously, with such automatic devices, a signaling or indicating system should be used, which at once will call attention to the fact, when the air supply is cut off. So important is the supply of air to such machines under normal operation, that it is recommended, where separate ventilating fans are used, that these be driven by motors operated directly from the machines themselves, so that whenever the voltage is on a machine, its blower will automatically be kept in operation. One interesting feature in such an arrangement is that, in case of a short circuit, either inside or outside the machine, which tends to kill the voltage, it also tends to shut down the blower. In this way the power is automatically cut off the ventilating fan.

In conclusion I may say that, at present, the problem of protecting such a machine is one of completely closing the inlets or the outlets, or preferably both. If power station designers would give as careful consideration to these points as is given to many other points in station design, the risk of fire damage in turbo-generators could be greatly reduced.

I. E. Moultrop (written). Mr. Lawler's paper points out some of the inherent defects of modern turbo-generators, but I question the value of the remedies he proposes. Modern turbo-generators run at a high rate of speed, the windings are as compact as possible, the windage of the machine is high and the insulation is quite inflammable; consequently there is a remarkably short interval between the time when the disturbance first starts and when the major portion of the exposed surface of the insulation is on fire. As soon as this takes place, the damage from an electrical standpoint has been done. I believe the practical solution of this problem is to bring all possible influence upon the manufacturers to devise and install non-combustible insulation, and I understand that there is some prospect of such insulation being brought out in the near future.

Paul M. Lincoln. Mr. Lawler says that the short circuit current of generators rises, in some cases, to as high as forty times the full load current. Although some turbo-generators have a short circuited current as high as that, it is not true of the modern turbo-generator. The designs put forth today will have a short circuit current of a value of somewhere between ten times and twenty times full load. This result is obtained by designing the generator so that the inherent reactance of the generator windings is higher than it is in slow-speed generators.

There have also been marked improvements in the method of bracing the generator winding so as to prevent motion under the tremendous mechanical strains that take place therein. I believe that I am perfectly safe in making the statement that so far as the protection against a mechanical stress due to short circuit is concerned, the modern generator does not require the addition of choke coils in order to make it safe, as suggested by Mr. Lawler.

I should like to ask Mr. Lawler whether it is the practice of the fire underwriters to insure generator windings against fire hazard originating within themselves? It is possible and in fact is standard practice, to install generators so that the windings can be completely consumed without any great fear of the fire communicating to the other parts of the building. So that a fire, if it does occur, may simply destroy the windings of the turbo-generator itself, without any great risk of its communicating anywhere alse.

Forrest E. Cardullo. It has been suggested that carbon dioxide be introduced into the air ducts of a turbo-generator for the purpose of smothering a fire, but it seems to me that it would be more practicable to introduce steam for this purpose. To do so, it might be convenient to bleed the turbine at a point where the pressure is 15 to 30 lb. gage, and to introduce the steam into the air duct through some form of diffuser. An equally satisfactory method would be to pass steam from a saturated steam line through a reducing valve. The control of the steam might be automatic, so that the steam would be introduced by the melting of a fusible link, in the same manner as is proposed for the closing of the damper. I would call attention to the fact that the fusible links ought to be placed in the exit duct as close as possible to the generator; on this account, it would probably be better to have the damper placed in the exit duct than in the inlet duct.

H. G. Reist (written). Having been intimately connected for many years with the design and construction of turbo alternators, I have found this paper very interesting, and, in general, I agree with the views set forth in it.

It is true that some protection can be gained by the use of fire-resisting materials on the end of windings, but we must not expect too much from this because most varnishes are more or less combustible, and the fire-resisting materials, such as asbestos or mica, are too much divided to offer a complete barrier against the flames passing through them. At one time my attention was called to the fact that a cement floor when soaked with oil burns as well as a wooden construction, and the same holds true of the insulating material on turbo-windings.

It has been pointed out that it is difficult to introduce an inert gas into turbo-generators. This difficulty could, however, be overcome by introducing the gas in front of the fan, instead of beyond it, so that it would be drawn in by suction.

Another possible means of protecting these machines is to arrange a damper in such a way that it will not only close

the inlet, but short circuit the outlet to the inlet, so that the additional air taken in will be air which has already passed through the generator, and, therefore, has its oxygen consumed. In European practice, where cotton filters have been used universally, there is danger of fire, and dampers have lately been introduced. How effective they are I cannot say. I have constructed dampers in some cases for turbo-generators, as long as six or seven years ago, but have not felt their utility sufficient to warrant the increased expense of using them generally.

So great have been the improvements in turbo-generators that fires are rare. Furthermore, the enclosed construction used on this type of machines makes it practically impossible for the fire to spread to the building.

Selby Haar. With regard to non-combustible coverings on the windings, it is perfectly feasible to get a non-combustible insulation, but the trouble is that non-combustible materials are usually pretty good heat insulators, and keeping the heat in his machine is just exactly what the designer is trying to avoid.

A. Blauvelt. Judging from the preceding discussion there is a difference of opinion and a lack of real knowledge as to how quickly the copper gets hot and how much copper is really affected as compared to the whole of the copper. Mr. Lawler's fourth suggestion for the introduction of a dead gas indicates that the arcing does not usually immediately heat so much copper as necessarily to fry the entire machine before the copper could cool. On this assumption I would make two suggestions: (*a*) that a more prompt action at a lower heat can be secured by an ether pulse glass, or several of them, than by a fusible link or links; (*b*) that chimney flue gas is a good dead gas always available in large quantity, for example, as used by the Union Carbide Company. The particular details of solenoids, and relays, of dampers, cooling tank, pressure blower, exciting circuit breaker, etc., are a matter of expense and should or should not be gone into depending on whether the annual direct and indirect losses through these particular fires do or do not exceed 20 per cent on the cost of the protective equipment necessary to cover all the machines in service.

Roger De Wolf.[1] In view of a recent experience in the burning out of a machine, I should like to hear from Mr. Lawler as to just how much he thinks the different methods suggested of cutting off the air supply and introducing carbon dioxide would reduce the damage to the machine. As pointed out by Mr. Moultrop, the time element is very short and there are a lot of things which might be done if there was time to do them, but in actual practice I believe the operating force would never get them done. In our case the short circuit resulted in burning off the main leads to the machine, and even if the air supply had been shut off, or the interior of the machine filled with carbon dioxide, I think the damage would not have been very greatly decreased. The amount of heat generated in the machine in a very short period of time is so great that the carbonization of the insulating material would be carried to quite an advanced stage, and although the actual combustion might not take place on the exterior surface, the insulation on the windings would be practically destroyed, irrespective of whether there is an atmosphere around those windings which would support combustion or not.

The Author. While it may be, as Mr. Lamme states, that there is no experience as yet showing that old machines are more liable to fire damage than new ones, it must be remembered that but very few turbo-generators can yet be considered old. This type of machine has only just passed through the development stage and therefore many new ones have given trouble, sometimes resulting in fire. In the future less trouble may be expected with new machines, but as they get older, the ordinary indication of age, such as short circuits, etc., may be looked for. It is reasonable to suppose that most machines will not be replaced until one or more short circuits have occurred, and owing to the condition pointed out by Mr. Lamme and by myself in the paper, fires will probably occur in many instances.

It is undoubtedly important that means be taken to keep air leakage down to an inappreciable amount, so that the atmosphere in the machine will not support combustion after the carbon dioxide gas is introduced. Some leakage would of course be expected but to offset it, the carbon dioxide gas should be admitted in abundant quantities. It is not necessary that all gas within the generator be carbon dioxide that a fire be extinguished, for I understand that a mixture consisting of 25 per cent carbon dioxide and the remainder air, will form an atmosphere in which fire cannot exist. The exclusion of air and admission of the inert gas are details which can undoubtedly be satisfactorily worked out.

Regarding Mr. Lincoln's question as to the practice of fire insurance companies covering damage by fire to electrical apparatus when fire starts from electrical causes within the apparatus, I cannot answer for all companies, but it is my belief that policies very seldom cover such loss. The fact that policies do not cover such loss makes it even more important from the standpoint of the owners of turbo-generators that fires be prevented in their machines.

Professor Cardullo suggests the use of steam for extinguishing generator fires. Steam may have the advantage that large quantities will be quickly available, but it has the disadvantage that it will thoroughly wet down the windings and in the case of old machines it might be difficult to avoid rewinding them, if they are wet down.

I have recently heard of some experiences which would indicate that steam was not as effective in extinguishing fire in enclosed places as has generally been thought. Carbon dioxide gas would extinguish fire more efficiently than steam, and being dry would not of itself cause injury to the machines.

In reference to Mr. DeWolf's question, the methods suggested in the paper are only to prevent occurrence of, or damage by, fire to the machine. They would not have any effect on the possible roasting of the insulation by continued heavy currents flowing in the winding. Short circuits have occurred in turbo-generators many times and probably most of them have not resulted in fire damage. It is probably a fact that where fire has not resulted, repairs to but a portion of the coils have usually been necessary and this would indicate that only in a small proportion of cases has it been necessary to rewind machines, due to a general roasting of insulation from the passage of current itself.

If the operators open the switches within a reasonably short time, as has appeared to be true in most cases in the past, roasting by current would not occur and it would appear well worth while to save the insulation from fire damage.

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EXTINGUISHING OF FIRES IN OILS AND VOLATILE LIQUIDS

By Edw. A. Barrier,[1] Boston, Mass.

Non-Member

The extinguishing of fires in oils and in most of the volatile liquids has always been a difficult problem and where fires of this kind occur the results are frequently very disastrous. Our most common extinguishing agent, water, works rather unsatisfactorily upon the majority of such fires, but it is still the only one available where heroic measures are required. Comparatively recently, however, there have been two or three other materials introduced for use as extinguishers which have shown some promise for dealing with these fires, and it is the purpose of this paper to discuss these materials and the conditions under which they prove the most efficient.

Not all fires in volatile liquids are difficult to handle with water. When the liquid is miscible with water this extinguishing agent can be successfully used. Examples of this kind are denatured alcohol, wood alcohol, grain alcohol, acetone, etc. Where the liquid is not miscible with water little or no effect is produced except to wash the burning liquid out of the building where it may be completely consumed or, if the quantity of oil is small, possibly to extinguish the fire by the brute cooling effect of a large quantity of water sprayed upon the fire. Soda and acid extinguishers are somewhat more effective than pure water, but even they fail under most conditions. The various grenades containing salt solutions which were formerly extensively exploited are of course practically worthless.

The only principles that can be made use of in extinguishing fires in volatile oils are, (*a*) to form a blanket either of gas or of solid material over the burning liquid which will exclude the oxygen of the air, or, (*b*) to dilute the burning liquid with a non-inflammable extinguishing agent which is miscible with it.

SAWDUST AND BICARBONATE OF SODA

To the blanketing type of extinguishers belongs sawdust. Paradoxical as it may seem, ordinary sawdust is an excellent extinguishing agent for certain volatile liquids, especially those of a viscous nature. A considerable number of experiments were conducted in the fall of 1912 by the inspection department of the Associated Factory Mutual Fire Insurance Companies, in the extinguishing of fires in lacquer and gasolene in tanks with sawdust, and the results were surprisingly satisfactory.

The liquids were placed in three tanks 30 in. long, 12 in. wide and 16 in. deep; 48 in. long, 14 in. wide and 16 in. deep; and 60 in. long, 30 in. wide and 16 in. deep. The sawdust was applied with a long-handled, light but substantially built snow shovel having a blade of considerable area. In every case the fires were extinguished readily, especially in the two smaller tanks which were about as large as any ordinarily employed for lacquer in manufacturing establishments.

The efficiency of the sawdust is undoubtedy due to its blanketing action in floating for a time upon the surface of the liquid and excluding the oxygen of the air. Its efficiency is greater on viscous liquids than on thin liquids, since it floats more readily on the former than on the latter. The sawdust itself is not easily ignited and when it does become ignited it burns without flame. The burning embers have not a sufficiently high temperature to reignite the liquid.

The character of the sawdust, whether from soft wood or hard wood, appears to be of little or no importance, and the amount of moisture contained in it is apparently not a factor, so that the drying out of sawdust when kept in manufacturing establishments for a time would not affect the efficiency.

It was found that the admixture of sodium bicarbonate greatly increased the efficiency of the sawdust as shown both by the shortened time and the decreased amount of material necessary to extinguish the fires. A further advantage of the addition of bicarbonate of soda is that it decreases the possible danger resulting from the presence of sawdust in manufacturing plants since it would be difficult, if not impossible, to ignite the mixture by a carelessly thrown match or any other ready source of ignition.

Although the efficiency of the sawdust is greatest on viscous liquids such as lacquers, heavy oils, japan, waxes, etc., in the tests referred to, fires were extinguished in gasolene contained in the smallest tank and also when spread upon the ground. In larger tanks the sawdust or bicarbonate mixture does not work so well since the sawdust sinks before the whole surface can be covered, whereupon the exposed liquid reignites.

CARBON TETRACHLORIDE

In recent years carbon tetrachloride has received considerable attention as a fire-extinguishing agent. This is due largely to the activity of certain manufacturers of fire extinguishers which use liquids, the basis of which is carbon tetrachloride.

This substance is a water white liquid and possesses when pure a rather agreeable odor somewhat similar to chloroform. A considerable proportion of the commercial article upon the market, however, contains sulphur impurities which impart a disagreeable odor to the liquid. The substance is quite heavy, its specific gravity being 1.632 at 32 deg. fahr. It is non-inflammable, non-explosive, and is readily miscible with oils, waxes, japan, etc. When mixed with inflammable liquids it renders them non-inflammable provided a sufficient quantity is added. Its vapor is heavy, the

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specific gravity being about five and one-half times that of air, consequently it settles very rapidly. As an extinguishing agent it operates by both the principles mentioned above, namely, it dilutes the inflammable liquid rendering it non-inflammable, or at least less inflammable, and it forms a blanket of gas or vapor over the burning liquid which excludes the oxygen of the air.

Although this paper is confined to a discussion of extinguishing fires in oils and volatile liquids, it may not be out of place to mention that the claims made by certain manufacturers producing extinguishers which use liquids, the basis of which is carbon tetrachloride, are grossly exaggerated. These preparations, none of which is more efficient than carbon tetrachloride, are not the equivalent of the ordinary water extinguishers for general use on such materials as cotton, wood, paper, oily waste, etc.

On volatile liquids, oils, etc., carbon tetrachloride has, however, shown very satisfactory results under some conditions, but the readiness with which a fire can be extinguished with it depends to a considerable extent upon the skill of the operator and the nature of the fire. In tank fires the length of time that the liquid has been burning is an important factor, and in such cases where the sides of the tank become heated the only way in which the fire can be extinguished is to squirt the liquid forcibly at the sides. If the carbon tetrachloride is squirted directly into the liquid it is much more difficult, if not impossible, to extinguish the fire.

The height of the liquid in the tank is also a very important factor. Where the liquid is low the sides form a pocket which retains the vapor and aids considerably in smothering the blaze. When the tank is nearly full, however, this condition does not exist, and it is then very difficult, if not impossible, to extinguish a fire in a highly volatile liquid, such as gasolene; only the most skilled operators are successful in these cases. The size of the tank or the extent of the fire if upon the floor is, as would be expected, of considerable importance. In tanks larger than about 28 in. by 12 in. more than one extinguisher and operator working at a time are necessary to extinguish a fire in such materials as gasolene. In one test where a tank 60 in. by 30 in. was used no less than seven operators were necessary, and even then it was only with the greatest difficulty that the fire was put out.

All of the above remarks apply to carbon tetrachloride in the ordinary one-quart extinguisher as generally sold. It is probable that a large extinguisher which could throw a large stream would prove more efficient, but on account of the great weight of carbon tetrachloride such an extinguisher would have to be specially designed to make it readily portable by mounting on a truck or some similar means. Expelling the liquid by means of a hand-pumping arrangement would probably be unsatisfactory, and it would therefore be necessary to force it out in some other way.

A few systems have recently been installed in which an elevated tank containing carbon tetrachloride was connected with automatic sprinklers or perforated pipes located in hazardous rooms where volatile and inflammable liquids are in use. So far as is known none of these systems have as yet been called upon to extinguish a fire, but there appears to be no reason why such a system should not provide excellent protection in special cases. In such systems it would be necessary to consider the safety of the workmen and furnish ready means of escape, since carbon tetrachloride is an anesthetic and where thoroughly sprayed through the air as from an automatic sprinkler it would probably produce rapid results.

The nature and effect of the fumes given off when carbon tetrachloride is thrown upon a fire is a subject which has received a great deal of discussion. When the liquid comes in contact with a fire the vapor is partly decomposed resulting in the evolution of a considerable quantity of black smoke which is undoubtedly finely divided carbon. Pungent gases are also produced which appear to be mostly hydrochloric acid with possibly a small amount of chlorine. Since carbon tetrachloride contains no hydrogen from which hydrochloric acid could be formed this substance must be produced by the action of chlorine on the gases arising from the burning material or upon the moisture of the air.

The fumes of carbon tetrachloride although of a very pungent nature do not produce any permanent injury under ordinary conditions where the operator can make his escape after he has inhaled all that he can stand, but they are a distinct handicap in fighting a fire and are one of the objectionable features to carbon tetrachloride as a general fire extinguishing agent. In large rooms or where a small quantity of carbon tetrachloride is sufficient to extinguish a fire the gases are of course less objectionable.

FROTHY MIXTURES

Another method of extinguishing fires in oils and volatile liquids which has recently been proposed and experimented with is that of using frothy mixtures. The idea seems like a very promising one and the tests which have been thus far reported indicate very satisfactory results. The idea was originated and has been developed in Germany. So far as is known no experiments have been conducted in this country.

The process consists essentially in causing two liquids to mix in a tank where foam is produced. The tank is made air-tight and sufficiently strong to permit of the foam being forced out by carbon dioxide under pressure, and the foam is conveyed to the fire by means of a line of hose. The exact nature of the liquids has not been disclosed, but one of them probably consists

of a sodium carbonate solution containing froth-forming ingredients such as glue or casein and the other an alum solution. The two on coming together generate carbon dioxide which produces froth. This froth is reported to be quite stiff and to shrink in volume but a comparatively small amount even after a period of half an hour.

A number of tests were conducted in the winter of 1912 in Germany; some of them on a considerable scale. In one case as much as 5 tons of crude naphtha in a tank was involved, and in another an area of 1300 sq. ft. of burning tar was used. In all cases the results were reported satisfactory, the fires being extinguished in a short time.

The frothy mixture undoubtedly owes its efficiency to its blanketing action in settling upon the surface of the burning liquid, thus excluding the oxygen of the air, and to the fact that the bubbles of liquid contain carbon dioxide which upon bursting produce an atmosphere in which combustion cannot take place.

According to the latest reports the matter is still in an experimental stage, various details regarding the form of apparatus, most efficient pressure, and design of nozzles being under consideration; but from what has already been done it would appear that the idea is a very promising one, and that this method of extinguishing fires in oils and volatile liquids will prove to be by far the most efficient of any that has as yet been suggested.

DISCUSSION

A. E. Cluett. As I understand it, the tank was an open one, of rectangular section, which does not represent the conditions in which these liquids are ordinarily found. They are generally in a closed tank, with a bung-hole of some description, and I would like to ask whether any experiments have been made on such receptacles, and also whether experiments have been conducted where the fluid has been spread out as it would be if it were spilled over a floor.

J. Stewart Thomson (written). The author of the paper occupies a position in connection with an organization insuring sprinklered risks, which makes no recognition whatever of devices for the extinguishing of fires other than by sprinklers. His remarks are the result of some tests made by him in connection with devices other than sprinklers.

It is generally known that fires in volatile liquids which are not miscible with water cannot be extinguished by the application of water. The reason is perfectly apparent; and that the way to extinguish a fire in volatile liquids of this type is to blanket the flame or to dilute the liquid with a non-inflammable extinguishing agent thus cooling the liquid to the point where it will not burn.

The use of sawdust in connection with fires of this character is not new. Almost every one has at one time or another used a blanket, towel or something similar for the purpose of smothering a fire. We all know that sawdust will float for a time at least on the surface of the liquid, and that if the sawdust is put on in quantity it acts as a blanket. As a practical fire extinguishing agent, however, the use of sawdust is not practical. In a large tank of burning liquid of the type described, before the surface can be covered with the blanket, much of the sawdust will sink below the surface whereupon the exposed liquid reignites.

As to the use of carbon tetrachloride as a means of extinguishing fires in oils and volatile liquids, there are some 40 different devices on the market employing this substance. Carbon tetrachloride has been found to be remarkably efficient; a quart of this liquid contains approximately 149 cu. ft. of fire extinguishing gas. As Mr. Barrier states, carbon tetrachloride contains sulphur impurities. Its use in a metal container results after a period of time in the corrosion of the metal. Extinguishers generally employing this chemical have not been found to have long life and corrosion of the metal results in the clogging of the working parts of the extinguisher. These extinguishers have the additional drawback of operating by air pressure; it is a well-known fact that air cannot be contained over any very long period in a metal container with valves, outlets, petcocks, etc.

The manufacturers of the Pyrene extinguisher discovered the efficiency of carbon tetrachloride as an extinguishing agent many years ago, but also that this article is corrosive in its action upon metals. It was necessary to alter the nature of carbon tetrachloride in respect to this before it could be used successfully in a fire extinguisher. They also discovered that it was possible to increase the efficiency of the liquid.

While the claim is not made by the author, the inference would be from his paper that carbon tetrachloride is virtually the same as the extinguishing agent employed by the Pyrene Manufacturing Company, in his reference to "the activity of certain manufacturers of fire extinguishers which use liquids, the basis of which is carbon tetrachloride." He is probably not informed that one quart of Pyrene will generate approximately 33 1-3 per cent more fire extinguishing gases than carbon tetrachloride; therefore it will cover more fire. The one-quart pump-type Pyrene extinguisher has been approved by the Chicago Laboratories, Inc., and is in universal use throughout the country; is uniformly recognized in every state for fires of the type described by him, and that its record of efficiency in respect to these fires is remarkable.

In stating that "these preparations, none of which is more efficient than carbon tetrachloride, are not the equivalent of the ordinary water extinguishers for general use on such materials as cotton, wood, paper, oily waste, etc., Mr. Barrier ignores the fact of the amount of extinguishing gas referred to above. Extinguishers of this type are more efficient in cotton fires and fires in oily waste, etc., than those employing solutions of water.

In the test where a 60 in. by 30 in. tank was used, where it required a number of operators to extinguish a fire of burning gasolene, he surely should have had no difficulty in extinguishing a fire in a tank of these dimensions if the extinguisher had been properly handled.

Mr. Barrier concludes that the use of soap-suds, described as "frothy" mixtures in extinguishing fires in oils and volatile liquids, will prove by far the most efficient of any that has yet been suggested, but statistics will not bear out the conclusion. This method has been employed to some extent on the Continent and in England for some time and experiments have also been conducted in this country which are

the subject of extensive reports. The progress of extinguishers working on this principle, however, has been inconsiderable as compared with the progress of other extinguishers, and notably, as compared with the progress made by the Pyrene extinguishers.

HENRY W. APPLETON. I would ask Mr. Barrier what he considers the proper proportion of soda carbonate in the sawdust, and what effect is produced on the sawdust to make it non-inflammable; that is, not only the percentage to be used to make it efficient in putting out the fire, but also the percentage to be used in rendering the sawdust itself non-inflammable.

LEWIS H. KUNHARDT. Mr. Thompson's statement, that the author occupies a position in connection with an organization insuring sprinklered risks, which makes no recognition whatever of devices for the extinguishing of fires other than by sprinklers, needs modification. It is absolutely at variance with the fact. Not only do the mutual companies give credit for many, and practically all devices which are used in extinguishing fires, but all the various sprinkler risk associations, underwriters and others throughout the country, are continuously studying all these other devices. Sprinklers are only a part of the fire protection of a piece of property. If other devices fail, the sprinklers come in and assist, and if the sprinklers should fail, there are the fire pumps, hose, etc. All the various fire protection engineers in the country are studying these problems and details thoroughly, and they do not give recognition *only* to the automatic sprinkler, although they recognize the value of it, and know it to be one of the best fire fighting agencies of today.

A. BLAUVELT. As just commented by Mr. Kunhardt, this paper by Mr. Barrier covers a subject in itself and one which is not tied to automatic sprinkler practice. The use of hand apparatus is universal in all branches of fire protection practice in preference to waiting for sprinklers to fuse, or to waiting for hose, and the greatest success of the professional fire department so far as the majority, or some 70 to 80 per cent of the fires numerically are concerned, is accomplished with hand appliances, or usually the carbonic-acid gas extinguishers carried on the man's back as he jumps off the hose cart.

The general scope of hand apparatus is fairly broad, depending on the combustible to be dealt with and whether ceiling as well as floor fires are likely to need extinguishment. Under its title, the teaching of Mr. Barrier's paper would seem to be that this subject of handling oil or volatile or chemical fires is not a mystery. Doubtless, as suggested by a preceding speaker, the paper can be bettered by giving more detail as to the best proportions for the several useful mixtures, but the main thing is that those who will can make up effective extinguishing compounds for volatile liquid or oil fires, not perhaps of the exact alchemic virtue of the trade compounds but probably obtain twenty times the quantity at like cost.

GORHAM DANA.[1] This paper seems to cover the field remarkably well, but there is one point I would like to bring up in connection with carbon tetrachloride, and that is the effect which the gas might have on metals in the vicinity. At a fire some time ago in a garage, an attempt was made to extinguish a pail of burning gasolene with these extinguishers. They not only failed to extinguish the fire, but the gases given off were of such a corrosive nature, probably hydrochloric acid, that the damage done to the metal work on the automobiles and in the garage, was more than the direct loss from the fire itself.

F. E. CARDULLO. The claim has been made in this discussion that one quart of carbon tetrachloride at atmospheric pressure liberates a volume of 149 cu. ft. of inert gas. A hasty calculation based upon my memory of the density of air gives for the volume of carbon tetrachloride vapor liberated from one quart of liquid a value of approximately 8 cu. ft. From the data given by Peabody in his steam tables, the volume of saturated vapor liberated at atmospheric pressure from one quart of carbon tetrachloride is 9.97 cu. ft. From data based upon the theoretical vapor density of carbon tetrachloride the volume of the vapor generated from a quart of the liquid at a temperature of 135° fahr., and a pressure of one atmosphere, is 9.8 cu. ft.

It may be added that if the gas given off occupied a volume of 149 cu. ft., it would be so light as to rise in the air and would have no smothering effect upon the fire. I would suggest that, in discussion, our members ought to be exceedingly careful of their facts, and not to quote any figures, or to make any statements, of the truth of which they are not absolutely certain.

THE AUTHOR. Replying to the question of Mr. Cluett, all the experiments with these materials were tried in open containers, since that is the way lacquer is ordinarily used in most metal-working plants. The metal parts are generally dipped into the lacquer. No tests were tried on closed tanks, and it would be difficult to use sawdust and bicarbonate of soda in such a tank. It might be possible to introduce carbon tetrachloride under such conditions. One of the tests did include a fire in lacquer spread over a wooden platform which served as a floor, and the sawdust appeared to work very satisfactorily in this case.

With reference to the comments of Mr. Thompson, I would say that I recognize that sawdust as an extinguishing agent is not new, but it is not well known, and this fact is shown by the experience we have had where this material has been recommended to manufacturing establishments throughout the country. At first their attitude was one of great surprise but after they had conducted a few tests of their own, they were very well pleased with the results. This shows that even though the idea may not have been new, it was at least not at all well known and the feature of mixing bicarbonate of soda with the sawdust is a new and valuable one.

It was not my intention to mention any particular commercial device, but in view of the fact that the Pyrene extinguisher has been brought into the discussion, I will say that with reference to the matter of the corrosive action of carbon tetrachloride, tests were conducted in a Pyrene extinguisher with an ordinary garden variety of carbon tetrachloride, the usual commercial article, in which the liquid remained in the extinguisher for over a year, but as far as could be seen after using a can opener there was absolutely no indication of corrosion. In certain cases where moisture or hydrochloric acid are present, carbon tetrachloride does cause some corrosion, but the indications are that if

[1] Manager, The Underwriters' Bureau of New England, 141 Milk Street, Boston.

a reasonably pure grade of the material is obtained, there is no serious trouble from this source.

As to the comparative efficiency of Pyrene and carbon tetrachloride, a large number of tests were made to compare the two liquids when both were used under the same conditions. As far as a number of unprejudiced observers could determine, there was no difference in the efficiency of the two. It is true that Pyrene contains a few other substances besides carbon tetrachloride, among which is a small amount of gum, which by the way is combustible, and a small amount of nitro benzol which is also combustible; both of these are detrimental rather than advantageous as far as extinguishing a fire is concerned.

With reference to the proportions of bicarbonate of soda and sawdust, the ingredients are mixed in the proportion of about 8 lb. of bicarbonate of soda to a bushel of sawdust. This proportion does not render the sawdust noncombustible but it does retard its ignition. It works in the following way: If a spark or any other source of ignition comes in contact with the mixture in the vicinity of where the bicarbonate of soda is located, the latter becomes heated and begins to give off carbon dioxide. This tends to make the atmosphere in that vicinity a non-supporter of combustion and serves to extinguish or retard the fire.

In reply to the question by Professor Woolson as to whether there is any tendency toward caking after the sawdust and the bicarbonate of soda have been standing for any length of time, I may say that this feature has been pretty thoroughly tested under the worst possible conditions and after a period of six or eight months hardly any indication of caking could be detected.

A SYSTEM FOR THE CONTROL OF AUTOMATIC SPRINKLER VALVES

By Fred J. Miller, New York
Member of the Society

Experience seems to have proved abundantly that the best of all means of fire protection is the automatic sprinkler. In theory, at least, it is supposed to be always ready for instant use, and it puts water where and when it is needed at the very beginning of a fire, before it has had time to assume threatening proportions, and usually before there is enough smoke to alarm the occupants of the building seriously or start a panic.

Every risk covered by the Manufacturers' Mutual Fire Insurance Companies must be protected by automatic sprinkler heads. It is impressive to note that the 19 companies, comprising what is known as the senior group, carry policies on industrial establishments aggregating over $2,500,000,000; employed in these factories there are, as nearly as can be ascertained, about 2,000,000 people, and so far as known not a single life has been lost in any of the buildings thus insured where the sprinkler heads were in commission at the time of the fire. A few lives have been lost in these factories, but in every such case the fire gained headway because, for one reason or another, the automatic sprinklers were out of commission at the time.

But sprinkler heads when once installed must then be kept ready for service when needed. Sprinkler heads are usually arranged in groups with a supply pipe for each group. In each of these main supply pipes is a valve by means of which water can be shut off from that section when necessary for repairs or by reason of the opening of one or more sprinkler heads, either in performing its normal service, or by accident. These valves cannot be locked open because it may be necessary in an emergency to close them as quickly as possible.

These valves introduce an element of danger and with this it is the main object of this paper to deal.

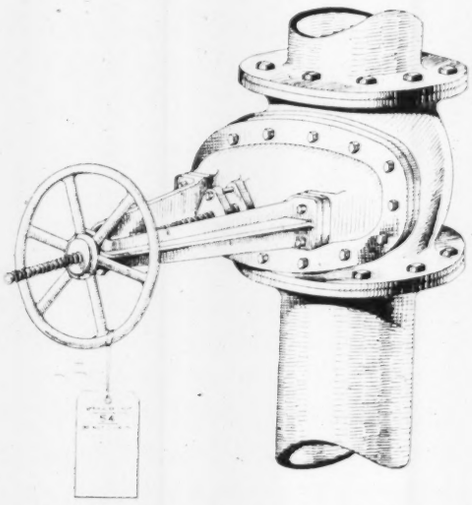

Fig. 1 Sprinkler Valve Open with Instruction Tag Attached

The inspectors of the Mutual Companies frequently find the valves referred to closed, and the sprinkler heads, therefore, of no more use than as though they had never been installed.

In an effort to lessen this evil, the Factory Mutual Companies occasionally send to their policy holders a circular letter on the subject of the danger of closed sprinkler valves. In a report, covering the months of April, May, June 1912, 72 cases were reported where inspectors found such valves closed. In 63 of these cases the number of sprinkler heads controlled by the closed valves are given, and these foot up to 8274 heads. Assuming that the cases in which the number of heads is not given would average about the same, this means that for this report, covering these months, nearly 10,000 sprinkler heads were found out of use by reason of valves closed when they should have been open.

In many cases no reason was assigned for the valves being closed, which means, we may infer, that the proprietors did not know how the valves came to be closed. It is inconceivable, of course, that they would go to

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the expense of installing automatic sprinklers and other fire protective devices, and then allow them to be thrown out of use if they had the organization and the discipline necessary to keep such devices always available.

The Remington Typewriter Company owns and operates five factories on which it carries in the Mutual Companies insurance policies aggregating about $6,000,000. These factories are protected by nearly 10,000 sprinkler heads, the water supply for which is controlled by 84 valves.

We have had from the start a system of inspection under which a watchman at frequent intervals examines each valve to see whether or not it is open. If found closed, the reason therefor is investigated, a report is made and an effort made to prevent a repetition of the error.

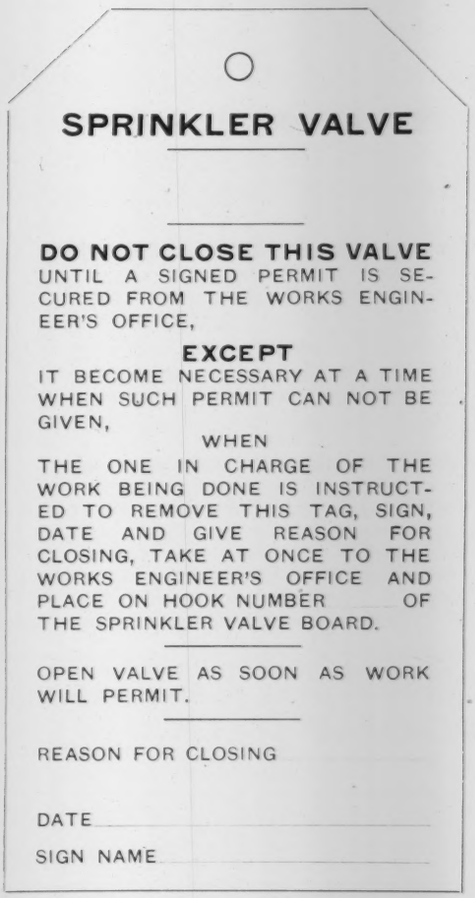
For many years no inspector of the Mutual Companies had found one of our sprinkler valves closed, until about a year ago when one was found. The reason revealed by an investigation is probable typical of a good many such cases. A mechanic had been making some repairs in a boiler house, over the boilers, and under the roof where the sprinklers were. Before going up over the boilers he closed the valve controlling these sprinklers as a precaution against accidental flooding. When he had finished the work he called down to his assistant to open the valve. He took it for granted that the assistant had done so, but for some reason the valve was not opened and the next day the inspector arrived.

To decrease the liability of valves being either closed without authority, or left closed when they should have been opened, we have devised and have in use in our factories the system to be described:

Our sprinkler valves are all numbered and upon each valve there is hung a tag as shown in Fig. 1. This tag is marked with the number of the valve to which it is attached, and, printed upon a tag is a prohibition of the closing of the valve without a signed permit to do so, except when, in an emergency, or for any special reason it must be closed at a time when no permit can be obtained, in which case it is to be detached and hung upon an indicator board with hook for each sprinkler valve. This is as directed by the card itself, and when it is done the blanks upon this card must be filled in to show by whom the valve was closed, when it was closed, and the reason for closing.

When such an emergency closing of the valve takes place, at a time when the person in charge of the indicator board is away, the watchman or other person having access to it goes to the board with the person who has closed the valve. Both these men then see that a red card complete but left blank is hung upon the board over the card removed from the closed valve. These are hung upon the hook numbered to correspond with the number of the closed valve. These cards thus hung upon this hook are intended to attract the notice of the person having the board in charge, who will, after proper investigation, fill out the blanks on the red card, hang the lower portion of it on the numbered hook corresponding to the closed valve, and attach the upper portion to the valve itself, alongside of the instruction tag, unless it shall have previously been re-opened.

In most cases it will be possible to obtain a written permit before closing a valve, and in such case the permit is given by the person in charge, by filling in the blanks printed upon the red tag (Fig. 3). It is then


SPRINKLER VALVE

DO NOT CLOSE THIS VALVE
UNTIL A SIGNED PERMIT IS SECURED FROM THE WORKS ENGINEER'S OFFICE,

EXCEPT
IT BECOME NECESSARY AT A TIME WHEN SUCH PERMIT CAN NOT BE GIVEN,

WHEN
THE ONE IN CHARGE OF THE WORK BEING DONE IS INSTRUCTED TO REMOVE THIS TAG, SIGN, DATE AND GIVE REASON FOR CLOSING, TAKE AT ONCE TO THE WORKS ENGINEER'S OFFICE AND PLACE ON HOOK NUMBER OF THE SPRINKLER VALVE BOARD.

OPEN VALVE AS SOON AS WORK WILL PERMIT.

REASON FOR CLOSING

DATE

SIGN NAME

Fig. 2 Instruction Tag Attached to Every Sprinkler Valve

torn in two at the dotted line, and the upper portion of it given to the person applying for the permit, who attaches it to the valve before closing it. The lower portion of the same red tag is hung upon the hook on the indicator board, numbered to correspond with the number of the valve.

The board is fastened to the wall of the room, or above the desk of the person having the system in charge, who may be the chief engineer, the superintendent, or one of his assistants, and the red tag hanging upon the hook is a constant reminder to him and a token to all others who may be interested, that the valve is closed. During this time the valve itself will have hanging upon it the red permit tag, which is a

sign and reminder so long as it remains there that the valve is closed and that the sprinkler heads controlled by it are therefore out of commission.

It will, of course, be perceived that the main feature of this system is the board with numbered hooks, which is in plain view of the factory official charged with responsibility for the sprinkler valves; a red tag upon this board is a danger signal, which means it should be taken off as soon as possible, and this can be done only by re-opening the valve. The card has written upon it the time at which it was expected that the valve could be re-opened. It is the business of the official having the board in charge, when this specified time has passed, to investigate the reason, and if a later time must be assigned, to indicate it upon the card and again take it up.

While the description of this procedure may make it seem somewhat formidable, in actual operation it is not at all inconvenient and it gives to some responsible person control of the sprinkler valves.

Of course this system of valve control is not presented under the impression that, by itself considered, it is a wonderful invention. So far as that is concerned it is no more than is being done every day for the accomplishment of various objects. It was devised to overcome a difficulty which, in view of all the conditions now existing, it seems rather important to eliminate in factories generally where sprinklers have

(SEE OTHER SIDE)

FIRE
SPRINKLERS SHUT

Attach this Tag to Valve

Valve No..... (Every Sprinkler Valve should be numbered, preferably with white paint figures at least 2 inches tall. May be on pipe close to valve.)

Shut on.....191 .....M.
Day of Week Month Date Hour

By.....
Name of man who shut the valve

To be shut
Only until.....191 .....M.
Day Month Date Hour

Reason for Closing.....

.....

Closing Authorized by
Tag No..... .....
Signature of Master Mechanic or other official

Don't remove this tag until valve is opened If valve is not opened at above time, fill out and attach a second tag extending time; also a third tag if need be.

Opened On.....191 .....M.
Day Month Date Hour

By..... (After opening valve take this tag to Master Mechanic's Office to be kept until next Insurance Inspector's visit.)
Signature of man who opened valve

This Coupon is to be torn off and hung on conspicuous peg board in Master Mechanic's Office until tag is returned signed by the man who opened valve. After return of tag, enter date of opening on this coupon, and send it to General Superintendent's Office.

FIRE SPRINKLERS ARE SHUT OFF

In.....
Name of Building and room

At Valve No.....on.....191 .
Day Month Date

By.....
Name of man who shut the valve

To be shut
Only until.....191 .....M.
Day Month Date

Reason for Closing.....

.....

Closing Authorized by
Tag No..... .....
Signature of Master Mechanic or other official

Opened by.....on.....191 .
Name of man who opened valve Date

(SEE OTHER SIDE)

Fig. 3 Form of Red Card used by the Mutual Companies

(SEE OTHER SIDE)

The danger of greatest loss from Fire in factories insured in "The Mutuals" to-day comes from Sprinkler Valves improperly closed or forgotten.

On almost every day the insurance inspectors find somewhere an important Sprinkler Valve shut. Often this occurs in factories which take pride in their order and discipline.

RULES.

1. Sprinkler valves must not be closed without authority from the Master Mechanic or other official, except in case of accident, when notice must be sent at once to the Master Mechanic.
2. A tag must be filled out and attached to the valve (inside or yard) every time a valve is closed.
3. Never shut off more sprinklers than necessary, and keep off only for shortest possible time.
4. Provide for immediate turning on of water in case of fire. Where large valves are involved keep a man near the closed valve ready to open it on notice.
5. For long and important shut offs provide extra watchman to patrol shut off area and notify Insurance Companies.

The Master Mechanic or Superintendent should provide in his office a conspicuous board with hooks, for these danger signals, and with supply of extra cards. Preferably a white board with a red border marked at the top—
"NOTICE OF FIRE SPRINKLERS SHUT OFF."

This method of Coupon Danger Cards was invented and tested in the Remington Typewriter Works and appears to be the best yet devised. Its adoption everywhere is urged by the Associated Factory Mutual Fire Insurance Companies.

A supply of these tags should be kept in Master Mechanic's Office, and may be obtained free of cost from the Associated Factory Mutual Fire Insurance Companies, Inspection Department, 31 Milk Street, Boston.

A few spare tags for emergency use should be kept conspicuously placed near desk of head of each department.

Fig. 4 Reverse of Mutual Companies' Red Card

been installed; it can save property from destruction by fire and may easily save lives of those employed in factories; for that reason it is here presented. It was not devised by myself alone, but, in accordance with the regular practice in our organization, the idea of it was presented to all our factories and it was then developed and perfected by the suggestions of the superintendents of those factories, Messrs. E. E. Barney, G. B. Brand, W. N. Brand, all of whom are members of the Society, and Mr. C. W. Burges.

Mr. John R. Freeman thought so well of it that it has been recommended by the Mutual Companies, including those of which he is president, and he and his associates have added some improvements to the red card, notably by arranging it so that the coupon which has been hung upon the board to signify a closed valve goes, when the valve is opened, to the superintendent, who is thus enabled to know how much of valve closing is taking place, and the reasons for it. This, I believe, is an excellent feature. The cards are now being supplied to all policy holders in the Mutual Companies and a reproduction of them is shown in Figs. 3 and 4.

In some of our factories, there are certain valves which, with the approval of the mutual companies are closed during the winter months. As it was thought to be undesirable that a red card should hang upon the indicator board, for some months, because danger signals constantly displayed are apt to cease to convey the idea of danger, they have proposed in one of our factories to cover the red card hung upon the board under such circumstances by a green card. That may be the best way to do it, but I am inclined to think that a better way is to leave off the red card entirely from the board and to put a memorandum into a tickler file so that the matter of reopening the valve will be automatically presented to the person in charge upon a predetermined date. This memorandum may appropriately be one of the white cards shown by Fig. 2 properly filled out; but the red tag should in all cases be hung upon a closed valve.

Mr. Freeman does not think so well of the white card. We use it because by means of it, always hanging upon a valve, a person whose business it may be to close a valve can learn and become familiar with what else is required of him besides merely closing a valve and then perhaps forgetting it. In the interest of the life-saving feature, the Remington Typewriter Company will supply such cards free to all who may wish to use them. Some are printed upon cloth for use when valves are out of doors, others upon cardboard. With the cards thus supplied it will be necessary only for the factory to provide for itself, the board with ordinary screwed brass hooks, numbered as shown—to put the board up before the eyes of a responsible factory official, and then to see that the system is used. And it is safe to say that if an owner finds that this or some such system cannot be maintained in effective operation, it may be taken as a symptom of the need of better organization in that factory.

DISCUSSION

George I. Rockwood. As Mr. Miller points out in his very interesting paper, the possibility of the unauthorized closure of automatic sprinkler system shut-off valves is the only remaining nightmare before the eyes of fire protection experts. In view of the record of fire losses due to such unauthorized or accidental shutting off of the water supply to sprinkler systems, it is singular that so little has been done to give any *automatic* protection against such a possibility. All the rest of the apparatus, such as the sprinkler head, the alarm valve, the dry pipe valve, and the system of sprinkler piping, has been developed to a high pitch of perfection; but this one point remains to be developed.

Impressed with the importance of this problem, I have invented and developed a simple and inexpensive piece of mechanical and electrical apparatus designed to supplement the very suggestions contained in Mr. Miller's paper. Mr. Miller desires the master mechanic, or the person in charge of the sprinkler systems in an establishment, to divide a printed card in the middle, fill out on each half the reason for closing the shut-off valve and the time when it may be expected to be opened and the pressure restored to the system again, and then requires him to tie one-half of the broken card to the stem of the gate valve and to carry the other half into the office and leave it with some authorized person who shall share with him the responsibility for shutting off the water supply.

This system would be, of course, entirely satisfactory provided the person who is required to carry it out really does so. It does not take very much imagination, however, to suggest many everyday reasons why it would be for the interests of such a person to omit such notice altogether, in which event there is a large possibility that the valve may be left shut, whether intentionally or inadvertently, for a long period of time. For example, a workman may go home to luncheon at noon leaving the valve shut, and something may interfere with his return; if the job is to be done at night, or the job of repairing the sprinkler system extends into the evening, the person notified by the other half of the card may be absent until the next day, in which case it might easily be that the valve would be left shut at least until his return.

The device which I have developed makes it *necessary* for the master mechanic to attach his card directly to an electric switch that controls an electric bell, which switch must be opened before he can attach it, and cannot be left open without the aid of a second person. This second person should be the one relied upon to see that the valve is actually reopened at the appointed time. He is also the one who would pay attention in case the valve was shut by some unauthorized person who had not first gone through the process of notifying the man in the office, and getting his assistance in holding the switch open, as this would result in turning in an alarm directly in the office. The way this is effected is by attaching an electric circuit closer to the valve stem of the main shut-off valve in a way such that any motion of the valve stem in the direction of shutting the valve will immediately cause the circuit closer to close the

electric circuit through the alarm bell and the red light in the office.

When the switch is opened through an arc of 180 deg. it will be held open provided the master mechanic has caused the circuit closer on the valve stem to close by shutting the valve; but this would result in an alarm in the office if the assistance of the man who is to be notified that the valve is to be shut has not actually been obtained to hold the controlling switch clear open against an electric magnet energized by the same current that lights the light and rings the bell, while the other man goes to the sprinkler riser and shuts the valve.

It will be observed that this mechanical and electric supervisory system is entirely supplementary to the system proposed by Mr. Miller, that it does not interfere with it in the slightest degree, and that its influence is positive if it actually works as intended, but that if it should fail to work there would be no interference with the operation of the simple card scheme. This system has been in operation in my own factory for several months, has been demonstrated to various underwriters, and seems to be quite satisfactory. No doubt about its operation, either theoretically or actually, has thus far developed.

The principle covering the development of this device is that more than one man should have something to say about the opening and shutting of sprinkler valves, and that the operations of the extra person should be mechanically interlocked with those of the person directly charged with the oversight of the sprinkler system. The device in question, in addition to being supervisory over the motions of the shut-off valves, is also a fire alarm and a water pressure alarm. In regard to the latter point, it may be said that the bell will ring and the light will light if the water pressure falls beyond a certain predetermined point.

In the history of sprinkler systems it has frequently happened that main shut-off valves have been shut with a heavy hand and then *apparently* open again, when, in reality, it was subsequently found out that the only part of the valve which opened was the stem, which had become detached from the plug. This may easily happen when the valve stem is shut with a big wrench in an outside gate and the stem is twisted after the valve has bedded upon its seats. In such a case as that, my alarm system would call the fact to the attention of the office automatically.

James P. Tolman. It appears to me that Mr. Miller's instruction tag does not afford all the protection that is possible. In our mill we have used a tag similar in style to that, but in place of the circular hole we have a slotted hole, through which is passed a piece of lace leather. The leather is also passed through the yoke and the arm of the hand wheel, which seals the valve. The lace leather is secured by a tubular rivet, easily applied. Each valve which controls sprinklers throughout the mill is always sealed, either open or shut. If it is a valve which should be closed in winter, it is sealed shut. If it is a valve which should be open at all times, it is always sealed open, and the tag requires any person breaking the seal to take the tag to the office. Recently the Mutual Insurance Companies have been sending out the tag shown in the latter part of the paper, and we felt that it was an improvement and adopted it. But we also retain our old form of tag, which we now make from green card, and this green tag is on every normally conditioned valve at all times, showing that the valve is sealed, and that persons who break the seal of the valve are to take the tag immediately to the office. If a valve has its seal broken, there is a notice. The red tag has supplanted the green tag, and every valve should always have one or the other tag upon it.

One of the objections made by Mr. Rockwood to the tag is that when a valve was marked with a red tag, it would never be seen by anybody unless he *happened* to see it. I want to say that it is the practice of all the mutually insured mills to have weekly inspections of the fire protective system. We have different men inspect the system for different periods of time. If a valve is wrongly marked, having the red tag instead of a green tag, it will be brought to the attention of the superintendent at least as soon as Monday morning.

Gorham Dana.[1] I agree with the previous speakers that the matter of a closed valve in the sprinkler system is a most vital point in the matter of fire protection in sprinkler-equipped plants. If we could eliminate the unnecessarily closed valve, the fire loss would be very materially reduced.

The scheme which one of the speakers proposed is an admirable one for certain conditions, but it does not seem to cover our conditions. In order to succeed with such a plan, it is necessary that a plant should be extremely well managed, with an efficient master mechanic and an efficient superintendent. There are a good many plants equipped with automatic sprinklers that do not have these conditions, a great many tenant factories, and a great many New York loft buildings, where there are many different firms in the building, and where it is difficult to get at any one to care for the sprinkler system. There are a great many small plants in various towns and cities that have no master mechanic who is worthy of the name, where the problem is very different.

The organization with which I am connected has been working on this problem for a number of years, and we have solved it in rather a different manner, which, to my mind, covers cases which this scheme would not cover. The plan is to have the valve fastened by the insurance inspectors. The tag which is used is slipped over the seal and is used in case the seal is broken to notify the insurance company. That is to say, the tag is similar to the one shown here, but somewhat differently worded, and in case the seal has to be broken to close the valve, the person who breaks the seal fills out certain data as to the circumstances (the reason for closing the valve, etc., the present condition of the valve, whether it was opened at once or not) and this information is put on the back of the tag and the tag mailed to the insurance inspection department. We find it to be extremely necessary in any plant which has not an efficient management, to have this information sent to the insurance interests.

Mr. Rockwood's scheme is a very excellent one, and I trust it will come into general use, but it has, however, one drawback: if a valve is closed for any length of time the alarm does not do much good. If a valve is closed for repairs, for an hour or two hours, you have got to shut off the alarm and cannot have it ringing all the time, and for that reason some notification to the people most vitally

[1] Manager, The Underwriters' Bureau of New England, 141 Milk Street, Boston, Mass.

interested, the insurance companies, is most desirable in my opinion.

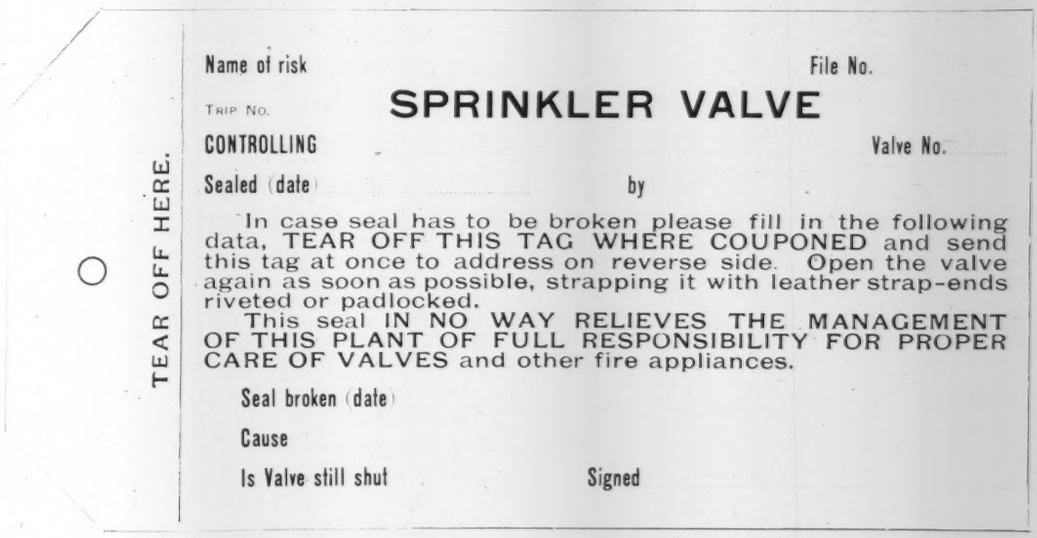
W. H. Kenerson (written). There can be no difference of opinion in regard to the necessity for keeping all sprinkler valves open, and if it is impossible to provide some of the mechanical supervisory devices, the scheme outlined in the paper is highly desirable. I take it that the purpose of the paper is to put before the public a scheme which anybody can employ, and the description of the system is in such detail that I beg to suggest one further simple expedient which will make it more effective. The majority of us have probably had difficulty, when using a system employing tags hanging on open hooks, in keeping the tags in place because of drafts, careless handling, etc. The simple expedient of turning the hooks upside down, will almost entirely obviate the difficulty. Such an arrangement would make this system much more reliable.

Charles H. Bigelow. While I believe the tag is a good thing, exceptional discipline is required to keep it up in every case, especially in places having only a small mechanical force of the class often employed, and where the office is a long distance from the valves. There the tendency would be, especially for a short job, for the man to shut off the valve and do the work, instead of taking the tag to the office, returning to do the work and then going back to the office after the tag, particularly as many of them regard such regulations as "red tape" if they think of them at all. The trouble is, however, that while the men may open up the valve in most cases, there is always the chance of the man being called away and forgetting to open the valve, so that probably the tag system, even if not kept up the way it should be, would be a help.

Pomeroy W. Power (written). The weekly inspection seems to be a very good system to use in connection with any method of keeping track of sprinkler valves. Our plan is giving good results. Every Thursday an inspector examines each indicator post gate and signs a tag, which is attached to the post, with his name and the date. After his examination of all sprinkler valves, the inspector signs a typewritten form of letter, which reads something like this: "I have this day inspected all of the sprinkler valves. They are all open and in good order, except——" Under the list of exemptions he fills in the location of any valve that is closed, the date when it was closed and the date that it is expected to be opened. That letter, after being signed by the inspector, is sent to the manager as a weekly report. After about four years use of this plan, we have had only one case of a valve being found closed.

Lewis H. Kunhardt. This whole question comes down to a matter of responsibility. Some one must be made absolutely responsible in a plant for the maintenance, for instance, of the sprinkler valves, the same as some one must be made responsible for the maintenance of any other piece of apparatus in the plant. A combination of the inspection and the tag will, we believe, fulfill these conditions of keeping the valves open. Of course, there is a fair possibility that something may slip up, but when it does slip up, the point is that you must have some responsible person to whom to look to see why it occurs, and that it does not occur again. Any one who tries this combined plan, that is, a system of inspection and tagging the valves, will accomplish the result.

F. J. Bryant (written). At our plant we have inspection cards giving in itemized detail the route to be followed, showing the location, size, type and duty of each valve, the location of each length of hose, each nozzle, tool, etc., as shown in Table 1. The man making the inspection takes the card and checks each item as he comes to it (if he finds it correct) and notes any discrepancies on the margin. After completing the round he signs the card, as the previous speaker said, and places it upon the manager's desk, who countersigns it and has it filled for further reference.


TEAR OFF HERE.

Name of risk File No.

Trip No. SPRINKLER VALVE

CONTROLLING Valve No.

Sealed (date) by

In case seal has to be broken please fill in the following data, TEAR OFF THIS TAG WHERE COUPONED and send this tag at once to address on reverse side. Open the valve again as soon as possible, strapping it with leather strap-ends riveted or padlocked.

This seal IN NO WAY RELIEVES THE MANAGEMENT OF THIS PLANT OF FULL RESPONSIBILITY FOR PROPER CARE OF VALVES and other fire appliances.

Seal broken (date)

Cause

Is Valve still shut Signed

Fig. 5 Form of Report Tag in Use by Underwriters' Bureau of New England

TABLE 1 INSPECTION RECORD OF HOSE HOUSES AND SPRINKLER VALVES

Andrew McLean Co., Passaic, N. J.

	Location	Sizes In.	State of Valve
1	Third St., gate valve, city connection	6	Open
2	Mill No. 1, napping depart., indicator post	6	Open
3	Mill No. 1, napping department, drip	2	Closed
4	Hose house No. 1, two-way hydrant, washers, spanners, ft. hose nozzle.		Clear
5	Boiler house, sprinkler line	3	Open
6	Boiler house, sprinkler drip	1½	Closed
7	Boiler house, 6-in. gate in line to mill No. 1	6	Open
8	Old Boiler house, drip	2½	Closed
9	Old boiler house, sprinklers under gallery	2	Open
10	Kier room, kier dye and breach room sprinklers	3½	Open
11	Kier room, drip for above	1¼	Closed
12	Old grey room, drip	2	Closed
13	Mill No. 1, second floor sprinklers for tower	1¼	Open
14	Mill No. 1, indicator post (tower entrance)	6	Open
15	Mill No. 1, indicator post (shipping room)	6	Open
16	Drip in shipping room	1¼	Closed
17	Hose house No. 2, one-way hydrant, washers, spanners, ft. hose nozzle.		Clear
18	Storehouse No. 2, indicator post	6	Open
19	Storehouse No. 2, basement drip	2	Closed
20	Office, indicator post	6	Open
21	Office, drip in pit of 1st toilet	2	Closed
22	6-in. valve in main rear shop	6	Open
23	Storehouse No. 3, basement drip	2	Closed
24	Storehouse No. 3, two-story end, indicator post	6	Open
25	Storehouse No. 3, two-story end, drip	2	Closed
26	Storehouse No. 3, one-story end, indicator post	6	Open
27	Hose house No. 3, two-way hydrant, washers, spanners, ft. hose nozzle.		Clear
28	Hose house No. 4, two-way hydrant, washers, spanners, ft. hose nozzle.		Clear
29	Hose house No. 5, two-way hydrant, washers, spanners, ft. hose nozzle.		Clear
30	Mill No. 2, indicator post	6	Open
31	Mill No. 2, drip	2½	Closed
32	Hose house No. 6, two-way hydrant, Spanners, washers, ft. hose nozzle.		Clear

The above has been examined by me to-day.
Date, ... Signed,.....
Countersigned by.....

THE AUTHOR. Before adopting this system of cards, we carefully considered mechanical and electrical devices for controlling our valves. There are men in our organization who have devoted a great deal of study to electrical devices and they at once thought of like means of controlling valve opening and closing, and proposed several schemes. We have, after careful study of the matter, come to the conclusion that it is better to depend upon our discipline and organization and to have some one responsible for these valves. If we put a mechanical or electrical device on the valves, any one would still be able to close it at will, and it would not involve the doing of anything else. We believed that notwithstanding the use of such a device we would have to go to some form of tag and report in addition. It is a fact that any automatic device, such as a water level indicator in a boiler, or anything of that sort, that is depended upon to indicate danger or abnormal conditions is apt to be depended upon too much; some day it will not work and then there is disaster. For our conditions at any rate, a thoroughly organized system for taking care of these valves and a definite placing of responsibility upon someone for their condition is the best. The seal idea for the card seems to be good, and would be a useful addition to it.

We had, as stated in the paper, before this card system was installed, a very thorough system of inspection for these valves, and we still maintain that inspection system. But the trouble about a weekly inspection is that if the inspector looks at a valve on a Thursday morning, the valve may be closed until the next Thursday morning and no one know anything about it except the man who closed it. Our system provides that someone must know about it; some responsible person must know immediately if the valve is closed, and we think that is important. Of course, there must be discipline, a definite placing of responsibility and strict accountability.

THE NEED OF MORE CARE IN THE DESIGN AND CONSTRUCTION OF ELEVATED TANKS

By W. O. Teague, Boston, Mass.
Member of the Society

The elevated or gravity tank for fire protection systems has been from the first an important limited secondary source of water supply, and its value has increased greatly with the increase in number and size of tanks installed generally throughout the country, especially in those cities and districts where the public water supply is of low pressure, as is the case in Philadelphia. The tanks are usually located above buildings in cities and on detached towers in the country, the 75,000-gal. tank on a 90-ft. tower at the plant of the Pratt Chuck Company, Frankfort, N. Y., as shown in Fig. 1, being a typical detached structure.

The tanks were first made of wood, but there are now as many being made of steel. Wooden tanks have been built up to 100,000 gal. capacity, although they are rarely larger than 60,000 gal., for above this capacity the steel tank is cheaper and more practicable. The cost of a 60,000-gal. tank of wood or steel erected on a 75-ft. steel tower is about $3000. Steel tanks are built in large sizes, one of the largest being of 1,200,000 gal. capacity; this one is 50 ft. in diameter and 90 ft. high, and is supported by a steel tower 130 ft. high.

Failures of tanks in service, involving loss of life and destruction of property, have shown the need of more care in the designing and construction of them. To insure the best results, the following features should have attention.

WOODEN TANKS

The tightness and durability in the wooden tank depends chiefly upon the quality of the lumber and the details of its construction. Selected tank stock only should be used consisting of white cedar, cypress, white pine, Douglas or Washington fir, or redwood, and the

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lumber should be free from sap, loose or unsound knots, worm-holes and shakes, and be thoroughly air-dried. Both the staves and bottom are usually made up of 2½-in. stock dressed both sides, for tanks up to 16 ft. in diameter and 16 ft. deep; for larger tanks 3-in. stock is used. Plank for this purpose should be full length without splices.

The strength of the wooden tank depends principally upon the size and spacing of the iron hoops. The importance of the matter of the hooping will be appreciated when it is realized that overstressing of even one hoop may result in bursting of the tank. The wooden tank being originally merely a development of the barrel where flat hoops were necessary to permit of tightening by driving them toward the enlarged middle, it was natural to use also flat hoops for the tank and the tank was also made tapered so that the hoops could be tightened by driving, although later they were tightened principally by hoop lugs. It was claimed that the tapered shape had also the advantage of preventing the hoops from dropping down over the tank, if it was allowed to remain empty and the staves to shrink from drying.

The tapered shape of tank is not important, however, since a tank which has been allowed to dry up, has been seriously damaged thereby and cannot be made tight without extensive repairs, sometimes necessitating the rebuilding of it. In fact most tanks are now made without taper and the hoops are found to remain where placed. The tapered tank costs somewhat more to build since the staves must be fitted more carefully and the design undoubtedly would have been entirely discarded long ago, except that some architects and purchasers believe a tapered tank presents a more pleasing appearance. The amount of taper is so small, being usually 1 in. per ft., thus giving a batter of ½ in. per ft. to each side of tank, that its absence is hardly noticeable except on very high and small diameter tanks. The only objection to the tapered tank, however, is its extra cost.

In the early studies of this subject, many serious failures of tanks were traced to weakening of the flat hoops by their rusting at the back where they bore against the staves, due to moisture from rain being retained between the surfaces of the hoop and staves. These failures were largely unpreventable, as it was difficult to properly inspect the condition of the hoops, and also impossible to paint them while the tank was in service. The use of hoops of round rod without welds has remedied this trouble as their surface is nearly all exposed for inspection and painting, and also they are not so subject to corrosion since the exposed surface of a round rod is much less than that of a flat bar or band of the same cross sectional area.

Another point of weakness in the flat hoop is at its connection to the cast iron lugs which is usually made by riveting. The use of round rod hoops, however, permits of a satisfactory connection to the lugs, but at first many tank failures resulted from the use of light cast iron lugs. These are now made of malleable iron, the best design being shown in Fig. 2. The hoops are so placed on the tank that the lugs do not come in a vertical line.

Round rod hoops are so spaced that the stress will not exceed 12,500 lb. per sq. in. when computed from area at the root of the thread. The proper spacing can readily be found from the following formula:

$$\text{Spacing of hoops (in.)} = \frac{\text{Safe load for given hoops (lb.)}}{2.6 \times \text{diameter (ft.)} \times \text{depth (ft.)}}$$

The depth used is the distance from overflow to point

Fig. 1 Typical Detached Tower Structure for Elevated Tanks

where hoop is to be located. The top hoop is placed 2 in. from the top of the staves and the spacing between hoops should in no case exceed 21 in. An extra hoop or two is placed at the croze to take the additional strain due to the swelling of the bottom planks.

The tank roof, since it in no way serves to retain the water, has usually been nothing more than a makeshift cover. In the early days a single flat roof was used on outdoor tanks, but this held the snow and ice and required strong joist supports to keep it tightly in place. The snow also interfered seriously with the opening of the hatch to give access to the interior of the tank. A conical roof was then built over the flat one which remedied these difficulties. It also greatly increases the efficiency of the roof in preventing radiation of heat from the tank water in winter as it provides a dead air space between it and the flat roof in addition to the one between the latter and the

water, thus reducing the cost of heating in freezing weather. The conical roof also gives a better appearance to the tank top. A well built roof is shown in Fig. 3. It should be tightly fitted around the tank top to maintain the dead air spaces.

Much trouble has resulted from leakage in the wooden tank, because it has not been firmly supported. The wooden tank is locally weak, not being of unit construction, and the lack of firm support has permitted working of the joints. It is supported only from the bottom, none of the weight being carried by the staves. Wooden beams were first used as supporting members, and these were placed on the roof of a building or tower as a grillage, and the tank bottom set on them. In time the wood rotted because of moisture from the tank bottom, permitting the tank to settle and

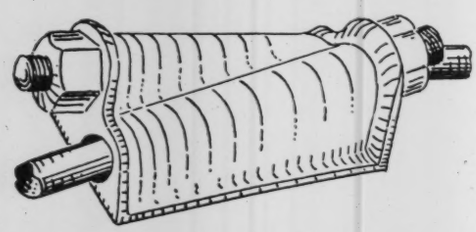

Fig. 2 Preferable Design for End Lugs in Malleable Iron for Round Rod Hoops

causing leakage; there was also danger of collapse of tank because of this weakening of the joists. The use of steel I-beams as grillage members as shown in Fig. 4 avoids these difficulties. The beams should not be spaced over 18 in. clear between edges of flanges, and the tank bottom is placed directly on the steel.

STEEL TANKS

The simplest form of steel tank is the flat bottom one and tanks of this type give satisfactory service, provided the bottom is supported by a steel grillage as in the case of the wooden tank. One possible source of trouble is from corrosion of the bottom, and to prevent this in so far as possible the bottom plates are made somewhat thicker than is necessary for strength alone, and the grillage I-beams are of a height and spacing to permit of inspection and painting of the bottom. When the tank is to be placed on a concrete tower, it may rest directly on a reinforced concrete slab with the bottom thoroughly grouted in place with neat cement.

The preferred form of a tank to be placed on a steel tower is that having a hemispherical or elliptical bottom. The construction in this form is cheaper than for the flat bottomed tank as the bottom is self supporting and a steel grillage is unnecessary. The entire bottom is also accessible for inspection and painting, and corrosion is reduced to a minimum since the plates are exposed to the air.

Plates for use in steel tanks are made somewhat thicker than is necessary for strength in order to make them durable against corrosion. The minimum thickness is $\frac{1}{4}$ in., except that $\frac{1}{8}$-in. plates are used for roofs. The plates composing the lowest cylindrical ring are $\frac{5}{16}$ in. thick for 60,000-gal. tanks and larger, and the bottom plates $\frac{5}{16}$ in. thick for tanks 75,000 gal. and larger.

One of the weaknesses of steel tank construction in the past has been poorly designed connections of the tank shell to the posts of the supporting tower. When the posts have a batter, as is usually the case, the inward thrust due to the horizontal component of the weight is provided for by a circular girder consisting of $\frac{1}{4}$-in. plate 24 in. wide, attached to the lowest cylindrical ring by an angle and stiffened by angles or a channel at the outside edge, as shown in Fig. 5. The posts also connect to the tank shell at this point and the design is such that the load will be transferred from the shell to the center line of the posts so as to avoid eccentric loading. A number of tanks built without circular girders have failed by the posts crushing in the tank plates. Others with the girder, but having eccentrically loaded connections to the posts have failed by bending of the upper posts.

As the hydrostatic pressure on the tanks is comparatively small, it is not necessary to provide standard

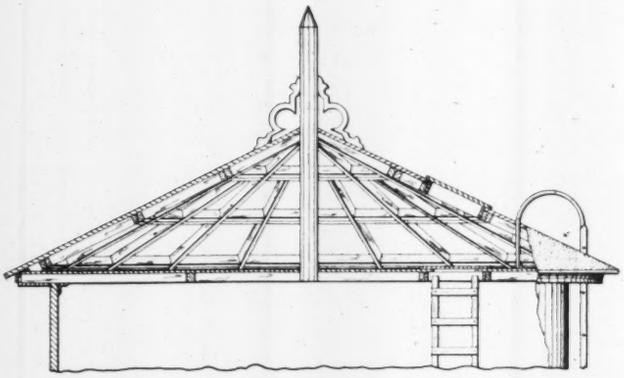

Fig. 3 A Good Design of Double Roof for Elevated Tank

riveting for the thickness of plates used. The joints of the plates should be riveted so that the unit stresses on the net section of the plates and rivets will not exceed 7,500 lb. for shearing and 20,000 lb. for bearing. The horizontal joints are single lap riveted, except between the lowest cylindrical ring and the bottom, which are double lap riveted. The vertical joints also are single lap riveted except those in the lowest cylindrical ring, which are double lap riveted. The rivets are entered from the outside and driven from the inside and inside seams caulked. One of the strong features of the steel tank is that when once made tight, it gives practically no trouble from leakage.

TOWERS FOR ELEVATED TANKS

Towers to support wooden tanks were originally built of wood, but with the increases in size of plant

buildings and extensions of them, considerably larger tanks and higher towers were required, and the builders, realizing the inadequacy of wooden construction under these conditions, began to make towers of steel. The managements not being experienced in structural steel designing, naturally selected the simplest design possible for the towers. The posts and girts consisted usually of two angle irons, placed apex to apex and strapped together at intervals of several feet by tie-plates shop-riveted to the angles. The column sections were spliced by angles which were shop-riveted at one end to the post; the other end was field-bolted in erecting the tower, as this was the simplest form of connection and the easiest one to make. Furthermore, it had the advantage that the bolting could be done by the regular erecters which made it unnecessary to have first-class mechanics in the erecting gangs and to carry special tools. This, however, was not good construction and the manufacturers are now field-riveting these connections.

The struts were at first connected directly to the posts by bolts. This construction is objectionable because the bolts are apt to work loose and it does not brace the parts. The construction now used is that of gusset plates riveted to the posts and girts. The

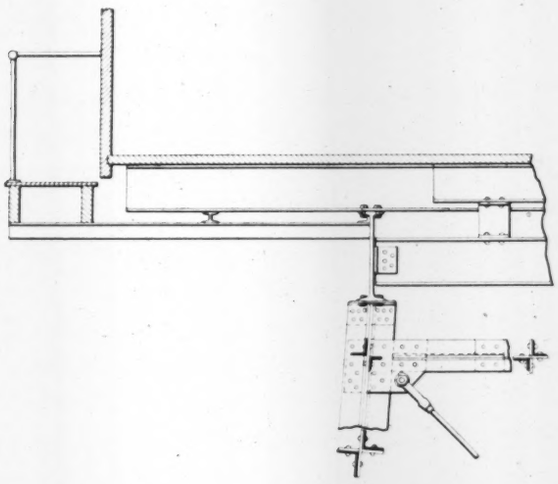

Fig. 4 Detail View of Arrangement of Steel I-Beam Grillage for Support of Tank

wind rods were also connected directly to the posts at the girts. The bolt holes, as originally inserted through the post angles, weakened the posts since they reduced the net section. The rods are now connected to the gusset plates. The arrangement of these parts is shown in Fig. 4. The diameter of bolt and thickness of plate are proportioned to provide proper bearing strength. The posts and girts of steel towers erected to support steel tanks, and to some extent wood tanks, are now largely made of channels latticed on both sides or having a plate on one side. Other shapes such as the Bethlehem H-beam and two channels with an I-beam between to form an H-section are also used to some extent.

Competition in the manufacture of these structures has resulted in the use of too high unit stresses and as a result the posts, figured on a conservative basis as represented in case of their structural work such as bridges, had a factor of safety of less than four and sometimes as low as two and one-half and failure has resulted. To obtain safe towers it became necessary, therefore, to set maximum allowable stresses. The loading of the structure consists of the weight of the structural and ornamental steel work, platforms, roof,

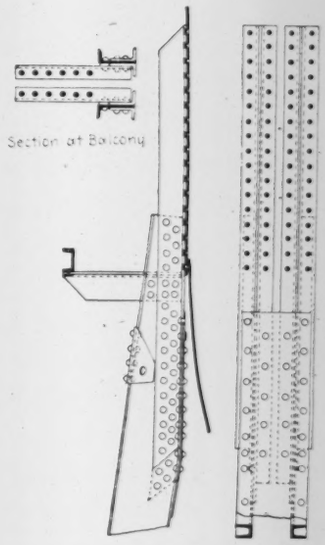

Fig. 5 Detail of Attachment of Tank Shell to Tower Post and Circular Girder Construction

piping, etc. The live load consists of the weight of the total volume of water; the movable load on the platform is assumed to be 30 lb. per sq. ft. and the wind load. The wind pressure is assumed at 30 lb. per sq. ft. on flat vertical surface and the wind load on the tank is taken as this pressure times 6/10 the projected area of tank and roof, and in the case of steel tanks, the curved bottom. The total wind load on the posts, struts, wind rods, ladders and riser boxing is assumed at 200 lb. per linear ft. of height of tower.

All parts of the structure are proportioned so that the sum of the dead and live loads shall not cause the stresses to exceed those allowable. The principal stresses in such a tower structure are axial compression on gross section of columns and struts, axial tension on net section of wind rods, bending on extreme fibres or net section of rolled shapes, built sections and struts, and shearing of rivets. The axial compression on gross section of columns and struts is determined from the following expression: $17{,}100 - 57\frac{L}{R}$, where L is the unsupported length of the members from centre to centre of connections in inches, and R the least radius of

gyration in inches; the ratio $\frac{L}{R}$ should not exceed 125 for columns and 150 for struts and minor members and the maximum compression allowable as thus determined is 12,000 lb. per sq. in. The axial tension on net section of wind rods must not exceed 12,500 lb. per sq. in.; the bending on extreme fibres or net section of rolled shapes, built sections and struts 16,000 lb. per sq. in., and the shearing for shop driven rivets, 10,000 lb. per sq. in. and field driven rivets 7500 lb. per sq. in.

The lower ends of the posts have not been as carefully designed as their importance requires. Frequently, in angle iron towers particularly, no special

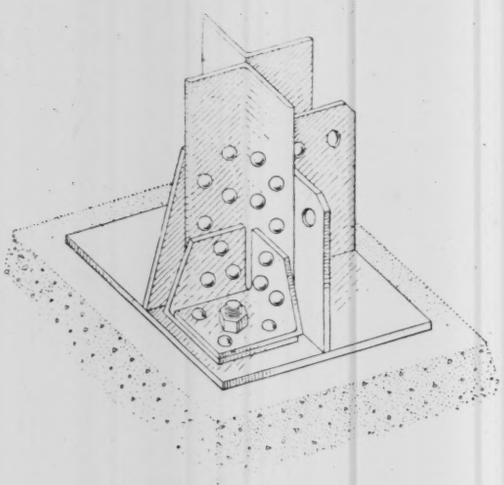

Fig. 6 Typical Construction of Footing for Angle Iron Column

attempt has been made to properly distribute the load to the base plate attached to the post footing. Cast iron plates were first used and the concentrated loading caused these to crack, resulting in collapse or in throwing the structure dangerously out of plumb with possibility of failure of the foundation under this post. The present use of steel plates has improved conditions, but the design must be such as to distribute the load to them as shown in Figs. 6 and 7, which are designs that are being used quite generally.

In anchoring the columns to the foundations, the diameter of the bolt at root of thread should be such as to withstand the maximum uplift due to the wind with tank empty, and to resist the shearing force at base plate. The bolts should be made from round wrought iron or mild steel rods without upsets.

FOUNDATIONS AND SUPPORTS

The foundation piers to support steel towers are usually made of concrete, consisting of one part portland cement, three parts clean sand and five parts broken stone. They are usually pyramidical in shape and proportioned to suit soil conditions. The allowable bearing pressures on soil will range from 1 to 5 tons per sq. ft., depending on the quality of the soil. Where the soil is moist or rather loose, a girt should be provided at the base of the tower to prevent spreading of the posts. The allowable bearing pressures for footings should not exceed 400 lb. per sq. in. for portland cement concrete and 200 lb. per sq. in. for ordinary brick work with portland cement mortar, except when tank is to be rested on building walls, when the bearing plate should be figured on the basis of 125 lb. per sq. in.

The weight of the foundation pier when buried at least two-thirds of its height should be equivalent to the calculated net uplift due to wind pressure with the tank empty, that will be transmitted to it; otherwise it should be one and one-half times that amount.

Where the tank structure is above a building, and the building walls are depended upon to act as supports, great care should be taken to determine that the construction is safe against collapse. In many cases, tanks are supported by building walls not originally built to carry them, but where a sprinkler system was later installed it was considered more convenient and cheaper to use the walls than to erect a detached tower for the tank. This has frequently been done

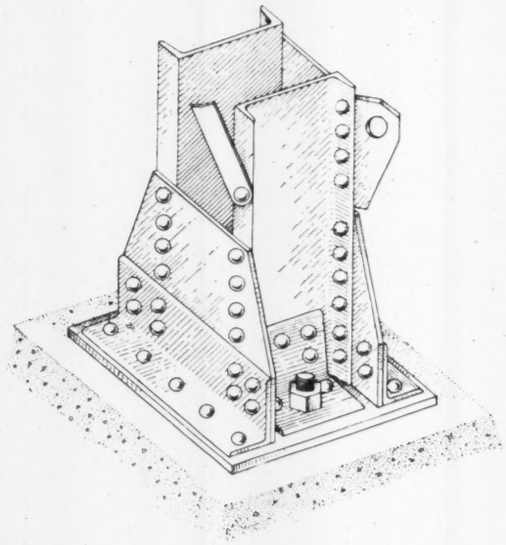

Fig. 7 Typical Construction of Footing for Channel Column

without making a thorough inspection first of the condition of the walls, and, largely through ignorance, the necessary care was not taken to distribute the load. Many failures have consequently resulted and there are no doubt numerous cases of this kind where the tanks are apt to fall at any time.

Inspection should be made of the quality and condition of the brick and mortar or other material used in the construction. The wall foundations should be examined as to construction and bearing on soil or rock. The condition of the bond between abutting walls should be noted and a general inspection made

for sizable cracks in the walls. The thickness of walls and size and spacing of window and door openings should be measured and calculations then made to determine if the load of tank, water and trestle can be safely distributed over the walls. All unnecessary openings should be bricked or otherwise solidly filled in, and it may be necessary to sacrifice some openings to obtain the required strength. When the walls cannot be altered to support the load, the additional support required can be obtained by carrying steel beams down inside the walls to a solid foundation, provided these do not interfere with occupation of or processes carried on in the building. Otherwise it will be necessary to provide a separate steel tower.

The proper strength of foundations is especially important because of the greater probability of loss of life from the falling of a tank from above a building as compared with the falling of a tank on a detached tower. The monetary loss is liable, of course, to be also much greater, as the water will undoubtedly wreck the building and cause heavy water damage. The building departments of cities endeavor to obtain proper construction, but unfortunately they do not always succeed. The possibility of trouble is increased because of the divided responsibility of the tank builder and the architect. The former seldom concerns himself as to the strength of the supporting walls, assuming that the latter has given the matter proper attention, so he goes ahead and erects the tank according to contract.

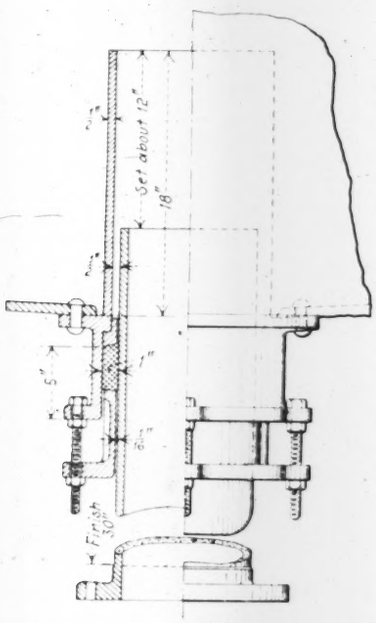

Fig. 8 Example of Proper Design of Expansion Joint for Steel Tank

GENERAL FEATURES

Tank fittings should receive careful attention to insure the reliability of the equipment. The discharge or riser pipe is more serviceable if made up of cast or wrought-iron pipe, flanged or coupled, than one made up of bell and spigot pipe, since the latter is apt to leak at the leaded connections, necessitating removal of the frost-proof boxing to permit of repairs. A tank and tower is constantly swaying from side to side and this tends to loosen up leaded joints. Furthermore, the increased rigidity of the flanged and coupled pipe permits the use of a minimum number of tie rods. There are usually four rods connected, one to each post, at girt connections.

The connection of the discharge or riser pipe to wooden tanks has usually been made by extending the pipe through ordinary cast-iron slip flanges bolted to the tank bottom on each side of the opening. The hole in the planks was cut larger than the size of the pipe to form a packing space which was filled when parts were first assembled. A better construction was used for steel tanks having a stuffing box and gland. Both types of joints were found to be unserviceable, however, the former because the joint could not be tightened when leakage occurred, and the latter principally because the iron to iron parts rusted together, which resulted in the breaking of some pipe fitting and the emptying of the tank. Examples of properly designed expansion joints forming tank connections for wooden and steel tanks are shown in Fig. 8. These have a bronze gland and ample clearance between the iron parts to prevent binding by corrosion. The packing space is large and the joint is extended within the tank bottom to form a settling basin, to prevent sediment getting into the yard pipe and clogging the sprinklers at time of fire.

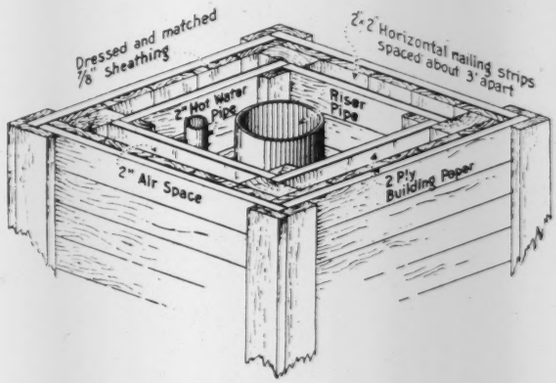

Fig. 9 Design of Efficient Frost-Proof Square Boxing for Enclosure of Riser Pipe to Tank Connection

A tightly constructed frost boxing should be placed around the discharge or riser pipe, and arrangements made for keeping the water heated by a hot water heater or a steam coil in the bottom of the tank. Designs of three-ply, two air-space boxings are shown in Fig. 9.

A tank level indicator or telltale is necessary to give a positive indication that the tank is full at all times. After many serious fires it has been learned that the tank had been partially or wholly empty at the start of the fire, and the lack of water had handicapped

the fire protection devices. Tanks may be left empty due to neglect, but usually so because of false indication of the telltale. The most used type of device for this purpose is the float in the tank water, operating a target sliding on a scale fixed to the outside of tank. Obviously, these are subject to sticking due to their mechanical construction and exposure to snow and ice in freezing weather. The ordinary pressure gage has been largely used but cannot be positively depended on, since it is seldom, if ever, tested and the parts stick,

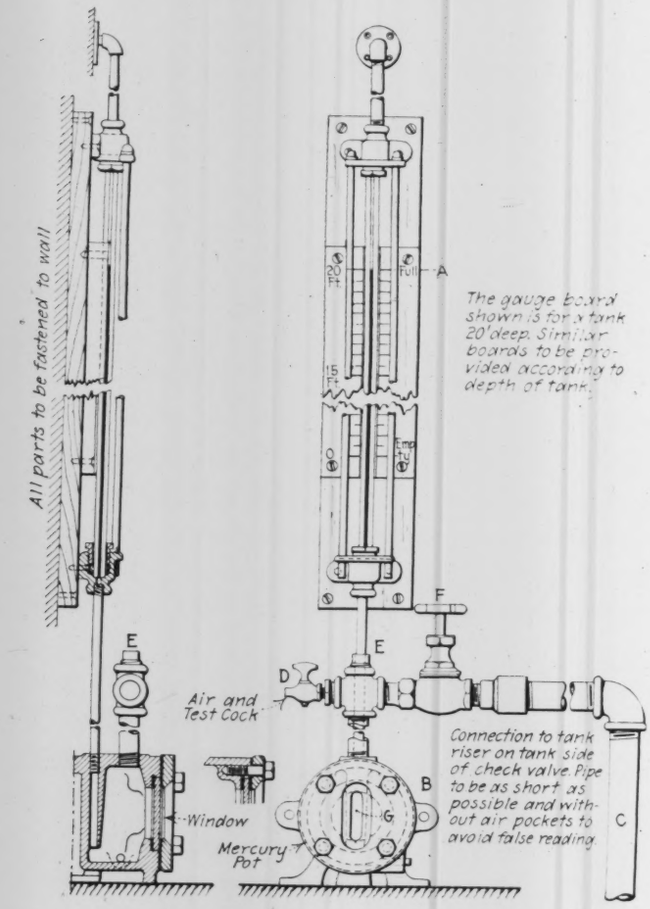

FIG. 10 DETAILS OF MERCURY GAGE FOR INDICATING WATER LEVEL IN TANK

causing false readings. There are several types of electrical telltales operated by a float, but these are complicated and easily gotten out of adjustment. Attention is also necessary to maintain the electrical current.

The most reliable telltale is undoubtedly the mercury gage, an adaptation of which for this purpose is shown in Fig. 10. This gage was developed by the laboratories of the Associated Factory Mutual Fire Insurance Companies. It should be placed indoors where it will be observed and cared for. The mercury pot is then piped to the riser pipe on the tank side of the check valve, and the gage board adjusted after filling the mercury pot. The gage is readily tested by opening the pet cock on the water pipe. If water continues to flow under constant pressure, the apparatus is in operative condition; otherwise, the pipe is clogged or there is a valve closed.

The painting of steel tanks and towers and of the iron hoops of wooden tanks is very important to prevent corrosion. Steel plates and shapes should be given the usual priming coat at the shop. The surface of the metal should be thoroughly cleaned of mill scale, rust and grease and be perfectly dry before applying the paint. A good paint for the first coat is made by mixing 20 lb. of red lead and 10 lb. of zinc oxide with 3 qt. of boiled linseed oil, the red lead and zinc oxide being ground in. This amount of paint will cover about 50 sq. yd. of surface. A second coat should be applied after structure has been erected. For this a more durable oil or asphaltum paint should be used.

The inside of a steel tank should be repainted, usually every two years, or oftener, if the paint shows signs of peeling or wear. The outside of the tank and the tower should be repainted at about five-year intervals. The surface should be carefully cleaned either by sand blast or by steel brushes or scrapers.

The iron hoops of wooden tanks should receive a priming coat as for structural steel and a second coat after assembly. They should be repainted when necessary. The advisability of painting wooden tanks exposed to the weather is an open question, although a large percentage of the tanks are painted. There is no doubt but that paint protects wood under ordinary conditions, but the objection raised to its use on tanks is on the ground that the tank water percolates through the staves and is prevented from evaporating as it is held under the paint and this is likely to set up dry rot in the wood. It is well known, however, that dry rot does not occur when wood is completely immersed but rather when it is in a moist condition in the presence of some heat. This objection is not considered well-founded and as a rule the tanks are undoubtedly preserved by painting.

The life of properly constructed equipments depends largely upon the care and attention given to them by property owners. The tanks should be used only for fire protection. The practice of using a foot or so of water from the top of the tank for mill purposes is objectionable as the tank collects a larger amount of sediment from the water which is constantly being supplied than it does when used for fire service only. This sediment is likely to settle in the sprinkler pipes and either clog them completely, or, if the sprinklers are open, seriously interfere with their discharge. If water is drawn from the bottom for mill purposes the tank may be empty when needed for fire service. Furthermore, the fluctuation in water level is apt to result in shrinkage of the upper ends of the staves of wooden tanks, causing leakage and hastening corrosion in the steel tank by the repeated wetting and exposure of the sides to the air.

DISCUSSION

J. W. KETLER[1] (written). Improperly designed supports for tank structures on buildings and the sub-foundations are likely to endanger life and property. As an engineer making a specialty of this work I come in contact with faulty designs, principally in the building itself. The fault does not lie entirely with the structural engineer, but in a great many cases with the architect. I would suggest stringent rules governing the installation of these outfits, especially the thorough examination of the building by a competent engineer or architect familiar with this class of work. I would also suggest, and would cooperate to further the acceptance of one uniform set of specifications governing the engineering manufacture and erection of towers and tanks, both on the ground and on buildings, by all insurance companies, and so far as possible by individuals, corporations or city building departments.

B. A. FREEMAN[2] (written). Lack of uniformity in the design of tanks and towers at present is well known to those interested in that line of work. Besides the cause suggested, close competition, the lack of ability on the part of most purchasers to discern the merits and demerits of designs submitted helps not a little towards that end. There is little novel or unusual in the construction of these structures. All of the problems connected with them have been solved before in connection with other engineering works. Now that elevated tanks and towers have come into general use for fire protection purposes, it is advisable both to protect the purchaser and the bidder who wishes to erect a good structure, that a specification be forthcoming which shall place all competitors on the same basis. A worthy attempt in that direction has been recently made by the engineering department of the Associated Factory Mutual Fire Insurance Company of Boston, and intelligent inspections in connection with such a specification should produce very good results.

BRYAN BLACKBURN[3] (written). Too much credit can not be given to Mr. Teague and his associates for the splendid service rendered along the line of tank betterment. The specifications issued by his office, if honestly carried out, will afford a high-class structure that is simple in design, economical in construction and very efficient in service. I have designed a vast number of elevated tanks for fire protection, and I can say without fear of contradiction that the tanks built under the requirements of Mr. Teague's office are beyond criticism.

I differ with Mr. Teague, however, in that it is allowable to single-rivet the vertical seams above the first course. As pointed out in my article on this subject in The Engineering Magazine,[4] the vertical seams should be double riveted, not so much for strength of joint, as to prevent the breaking of the caulking edge by breathing tendency of shell due to change in water level; also it is my opinion, based on experience, that the riveting should be closer than is theoretically required for efficiency of joint, in order to ensure that the plates be well drawn together under field riveting. The joints in the main column at strut points should be milled to ensure full bearing.

The formulae and stresses set forth in the paper for main members are correct and ample, but I would suggest that, while the struts should be of such section as to provide for all live and dead loads, and that the depth of strut should be such that the unit stress due to weight of member should not exceed 4000 lb. per sq. in., still my experience indicates that more often the sizes of these struts are fixed by the requirement that no strut shall exceed 150 radii of gyration in length.

In the using of the Bethlehem H column for main columns, as suggested by Mr. Teague, care should be exercised to see that the column lengths do not exceed 125 radii of gyration. The standard practice in these elevated tanks allows very long column lengths in the latticed channels columns and this has led some inexperienced designers to employ H shapes in too long lengths, with results that are not pleasing, and in several cases that have come under my observation, partial failures have resulted, not from any inherent defect of the H sections but from misuse.

Stress must be laid on the fact that the so-called balcony used on hemispherical-bottom steel tanks is not an ornament but a horizontal girder subjected to large loads due to the horizontal component of the stress in the column.

A. H. HAYES (written). It is generally conceded that for all structures on which are dependent the lives of men, or the safety of property from destruction, too much care can not be taken in their design and construction; this is the business of the designing engineer. It is also his duty in this day of efficiency, so to plan his structure that he may use no more material than is necessary to take care of the maximum loading which may occur, with, of course, the proper factor of safety.

In the latter part of the section on towers, the author states that "the total wind pressure on the posts, struts, wind rods, ladders and riser boxing is assumed at 200 lb. per lineal ft. of height of tower." This is taken to mean that for all towers carrying tanks, whether of 10, 20, or 100,000 gal. capacity, the wind pressure must be assumed to be the same. This appears inconsistent, inasmuch as the size and shape of the members will vary with the style of construction, and the loads they are to carry.

The writer has, in several years experience, designed many towers to carry the smaller tanks on which the wind pressure, taken at 30 lb. per sq. ft. of flat surface, did not reach 150 lb. per vertical ft.; also others of larger capacity, where the wind pressure greatly exceeded 200 lb. per vertical ft. This is a small consideration when designing low towers, but with comparatively high towers where the wind stresses at the base of the tower equal or exceed those caused by the weight of tank, tower and water, the difference amounts in some instances to 15 per cent. Therefore, a strict economy of material is not possible.

I wish to present for consideration another point along this line not brought out in the author's paper, but which is embodied in the Specifications for Gravity Tanks and Towers, recently published by the Associated Factory Mutual Fire Insurance Companies, with which specifications, it appears, the author is largely to be credited; that is the practice of assuming that the wind pressure on the tower is the same when acting in the direction of the diagonal of the

[1] Chief Engineer, Wendnagel & Co., Chicago, Ill.
[2] Engineer, The Rusling Company, New York
[3] Assistant Engineer, R. & D. Cole Mfg. Co., Newnan, Ga.
[4] Elevated Tanks for Fire-Protective Service, p. 385

tower as when acting in the plane of the bents. This is not correct when the posts are made up, as with many of the smaller towers, of two angles placed corner to corner forming a star section as illustrated in Fig. 4. Here the wind surface, when the wind is acting in the direction of the diagonal of the tower is $\frac{S}{\sqrt{2}}$. Therefore, the maximum compression stress in the post on the leeward side of the tower, due to wind on the posts, is exactly the same as when the wind is acting in the plane of the bents. The pressure in the struts, wind rods and riser boxing is the same whether the wind acts in one direction or another, and the practice of increasing these stresses by the square root of 2 is correct. But in some towers the wind pressure on the posts is the greater part of the total. Take a case where 50 per cent of the total wind pressure is on the posts; then instead of increasing the total wind stresses by the square root of 2, only 50 per cent should be thus increased.

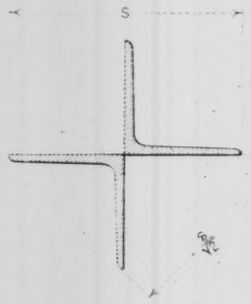

Fig. 11 Surface Exposed to Wind in Post formed of Two Angles

Taking into consideration the fact that an assumption of 200 lb. per vertical ft. in many cases raises the total actual stresses in the posts 15 per cent, and that the latter assumption increases them another 10 per cent, it appears that the author has gone even beyond the limits of conservatism, and in order to meet these requirements the manufacturer is compelled to use considerably more material than is needed. This matter should be left as an incentive to each individual engineer to design his structure so as to present the least possible wind surface, and thus produce an economical design.

A. Blauvelt (written). I take issue to the statement recommending a water level indicator to be placed indoors. Such an indicator is limited to showing the water level in the tank and may not do that because the operator can not be relied upon to use the test cock alluded to, to prove that the connections are clear. As a matter of field service, it is preferable to use a sight overflow pipe placed vertically inside the tank, with the upper end at the desired full elevation of water and the lower end extending through the bottom of the tank and angled over for easy seeing. By such an indicator, much more is accomplished. The operative condition of the means for filling the tank is proved, the operator can not guess that the tank is full enough; he must fill the tank to get an indication, he must look at the tank structure and thereby is more or less compelled to inspect it, and if the heat has failed and the tank frozen, the top of the sight pipe freezes shut and the tank gives warning of ice by overflowing around the top of the tank instead of at the sight pipe.

G. A. Smith[1] (written). The paper is principally an abstract of the author's specifications covering gravity tanks and towers prepared for the Associated Factory Mutual Fire Insurance Companies of Boston. There are a few points in them with which I do not fully agree, but on the whole consider that the specifications cover the field in very good shape. There are two points, however, which I might mention and on which I would like to have the discussion of different members of the Society:

In the section on Towers for Elevated Tanks, Mr. Teague gives a formula for unit stress in water tower columns. This formula gives a unit stress of 12,000 lb. on the basis of 90 radii. It has always been my contention that a higher unit stress is permissible in the design of water tower columns for the reason that the entire load is quiescent and is entirely dead load. There might be some question raised on this point due to the fact that a certain portion of the column load is caused by wind pressure; however, it is the general practice to permit a higher unit stress for wind loads than for either dead or live loads.

It is a general practice of most engineers in the design of steel structures, such as bridges and buildings, to use a higher unit stress for dead loads than for live loads. For instance, Theodore Cooper specifies for bridges a unit stress in chord compression members of 15,000 lb. for dead load and approximately 7000 lb. per sq. in. for live load, both of these stresses being based on 90 radii. On a similar basis, I believe that a unit stress of 15,000 lb. per sq. in. for water tower columns is conservative. I would mention, however, that on account of there being so much sentiment against this high unit stress, the company which I represent has adopted a unit stress of 12,000 lb. per sq. in. for columns in their standard water tower specifications.

Another point on which I do not quite agree with Mr. Teague is the expansion joint illustrated in his paper. The illustration is not quite clear as to the kind of metal used in the different parts, but it is his requirement to use cast iron in the pipe sleeve and the collar, and brass or bronze in the follower and adjustment bolts. I contend that this expansion joint will not permit proper operation after it has been used for some time. It is my idea that the cast-iron sleeve will corrode or rust more or less above and below the gasket, and in fact will corrode to some extent on the surface covered by the gasket. After this sleeve has become more or less corroded, I believe that it will not slide freely through the gasket, and in fact there is considerable danger that the riser pipe would probably give in some other point before sliding in the expansion joint as intended. I cannot see why the brass follower gland used by Mr. Teague is any better than a cast-iron gland for the reason that the clearance between the sleeve and the follower is sufficient to prevent any serious adhesion by corrosion.

My idea of an expansion joint which would always work freely, would be to have a brass covered sleeve instead of cast iron so that the surface coming in contact with the gasket would not be affected by corrosion and therefore would slide freely through the gasket.

C. S. Pillsbury[2] (written). Mr. Teague has done a great deal to bring about the general adoption of proper methods

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[2] Chicago Bridge & Iron Works, Chicago, Ill.

in the design and construction of sprinkler tanks, and his specifications are generally recognized by the manufacturers as fairly representing the best present practice in that class of work. In this paper, he outlines a number of suggestions as to proper unit stresses, plate thicknesses, etc., all of which tend to result in a safe and economical structure. The provisions which probibit bolted connections and reduce the shear on field rivets are especially good.

As Mr. Teague says, it is of great importance to design the details so they will develop the full strength of the main members. To those familiar with railroad bridge shop practice, this statement will seem superfluous, but, as a matter of fact, practically every failure of an elevated tank can be traced to an eccentric top post connection, insufficient provision for the horizontal thrust at the top of the posts, poorly made column splices, or some other oversight due to inexperience. To prevent excessive stresses in the tank shell, the number of posts must be proportioned to the diameter and depth of the tank, and provision must be made to resist the torsional moment due to the curvature of the sides. It is also necessary to provide for a number of severe forces other than gravity and wind loads. This last statement is well emphasized by the illustration of a water tower loaded down with ice due to the continuous overflowing of the tank in cold weather. It is only a carefully designed structure that can undergo such treatment without injury.

Following are stress formulae used by the Chicago Bridge & Iron Works which may be of interest in connection with Mr. Teague's paper:

Tank Sides and Bottom. The stress in pounds per linear inch in the sides of a cylindrical tank is $2.6 \times H \times D$, where D = the diameter of the tank in feet and H = the head of water in feet. The maximum stress in a hemispherical bottom is $1.3 \times H \times D$ and in an elliptical bottom $2.3 \times H \times D$. The last two formulae are closely approximate, H and D being the same as before, except that in this case H should be taken as the total depth of the tank.

Posts. The vertical component of the dead load post stress is equal to the total water and metal load divided by the number of posts. The vertical component of the wind stress equals the following:

3-post tower..... $\frac{M}{0.75\,D}$

4-post tower..... $\frac{M}{1.00\,D}$

6-post tower..... $\frac{M}{1.50\,D}$

8-post tower..... $\frac{M}{2.00\,D}$

where M = moment of wind about panel point at the bottom of the post section considered and D = diagonal of tower at the panel point about which moments are taken.

Rods. There is no dead load stress in the rods. The wind stress equals the following:

3-post tower..... 0.500 $(V-V')$ Sec. A
4-post tower..... 0.707 $(V-V')$ Sec. A
6-post tower..... 1.000 $(V-V')$ Sec. A
8-post tower..... 1.307 $(V-V')$ Sec. A

where V' = vertical component of post stress in panel above;
V = vertical component of post stress in same panel as the rod,
and A = angle rod makes with the vertical.

Struts. Except where the batter of the posts changes there is no dead load stress in the struts. The wind stress is approximately the horizontal component of the rod stress in the panel below.

THE AUTHOR. As stated in the paper and as emphasized by Mr. Ketler, the possibility of danger to life and property from elevated tanks is greatest when they are erected above buildings. I fully agree with Mr. Ketler that buildings should be carefully examined by a competent engineer to ensure that they will safely carry the load to be imposed upon them. His suggestion that a standard specification should be adopted by all parties interested is a timely one, as the recently developed specifications of the Associated Factory Mutual Fire Insurance Companies can be used as a basis, such changes or additions being made as seem necessary so that the standard will thoroughly cover all conditions. It would be desirable to have this Society assume the leadership in the work.

Mr. Freeman also advocates uniformity in the design and construction of tanks and towers, and recommends a standard specification following along the lines of those of the Factory Mutual Companies.

In reply to Mr. Blackburn's suggestion that the vertical seams above the first course be double riveted, I have not considered it necessary to advise this, since experience with the single-riveted joints has thus far been quite satisfactory. Certainly if much trouble from leakage at these joints should be experienced, the double riveting would be advisable.

Mr. Hayes has brought up a point which should receive more careful treatment, i.e., the wind load on the tower members and pipe fittings. I have followed current practice in assuming the total wind pressure on these members as 200 lb. per linear foot height of tower and have not, as yet, attempted to vary the pressure to suit various heights and types of towers, although I believe that this is advisable, especially in the case of towers to support tanks for other uses, such as water works supplies. The 200 lb. pressure gives reasonably accurate loadings for sprinkler tank towers, as the height of these is fairly constant within limits. A closer approximation of the loading, even for these towers, would, however, be appreciated by the designing engineer.

The further point which Mr. Hayes mentions, that the actual wind pressure varies according as to whether the wind blows at right angles to plane of the bent or diagonally is, of course, correct, especially for angle-iron towers. As a further refinement in determining the wind load on the structure, it would be well to give this matter consideration.

Mr. Blauvelt's comments regarding the use of the overflow to determine if the tank is full, represent the best practice, and I would say that the use of a mercury gage as a telltale is intended merely as a constant indication of the water level, in place of the unreliable float and target telltale and other devices.

In reply to Mr. Smith, 12,000 lb. per sq. in. is considered a proper maximum allowable unit stress in compression for tank towers by most manufacturers and engineers. This stress is none too conservative, in view of the very special type of the structure where failure of one post member results in immediate and complete collapse. Furthermore, the towers are exposed to the weather, and as they are usually the property of comparatively small companies unfamiliar with the proper care of steel structures, they will not be in-

spected and kept painted as will steel railroad bridges and other structures, and so the steel members should have some additional thickness, in order that they may remain serviceable even after some considerable corrosion has taken place.

I agree with Mr. Smith that a brass or brass covered pipe at the expansion joint is preferable to the iron pipe and believe that this would remove the last possibility of binding through corrosion in the present design. This improvement may be secured in time, but the expansion joint shown is so much better than what has been used that it seemed wise not to add further to its cost at this time, since there undoubtedly would have been serious objections raised by the manufacturers for commercial reasons. The advantage of the brass follower is, of course, its non-corrodibility, which will permit its being moved to tighten the packing even if the iron pipe is corroded, as mentioned by Mr. Smith. The oil lubricant with which the packing is saturated will naturally prevent any appreciable corrosion of the pipe where it bears on it and so permit of movement of the pipe without injury to the packing.

The suggestions made by Mr. Pillsbury are important and the data which he has given regarding stress formulae will undoubtedly be useful.

FIRE PUMPS

By Ezra E. Clark,[1] Boston, Mass.

Non-Member

Broadly speaking, any device by which water can be thrown on a fire is a fire pump. In its simplest form, it is a bucket of water and a man. In the earliest days the bucket was supplemented by huge syringes in the form of a bladder or bellows. Later they were made from brass cylinders and were called "squirts." From these crude appliances were developed the hand and steam fire engine around which cluster the memories of many exciting contests during the last century. These devices, however, are all portable in character, and valuable time is often lost in bringing them to the scene of action. Manufacturing properties, particularly, were often located at such a distance from fire engine stations that prompt service was impossible. The incalculable value of a few gallons of water at the beginning of a fire became self-evident, so that pumps fixed upon the premises, connected to a water supply and a source of power, were introduced. Later these were connected to a system of piping about the yard and in the mill, and the pump then became available to supply sprinkler heads, or furnish fire streams from hydrants.

In this paper, the term fire pump is to be used in its restricted sense, i. e., a pump that is installed in a fixed position for fire purposes. In this sense there are three or four distinct types, generally acknowledged; rotary, duplex, centrifugal, and power pumps, any one of which, of course, could serve as a fire engine by mounting it on wheels and providing a source of power.

The type of pump to be selected should be determined by the character of power available for the purpose. Naturally the most reliable source of power at any situation would be chosen, and then a pump selected that can best be driven with that power. This should be the general rule. Every type of pump, however, has its own limitations and these must be kept in mind when studying the whole problem. The natural selection would be a pump that can run at or near the speed of the prime mover. One instance has been noted where a centrifugal pump was connected to a water-

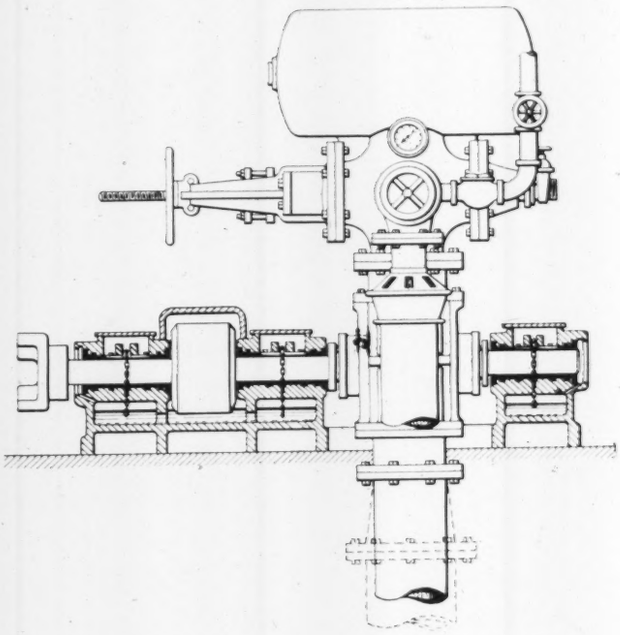

Fig. 1 Part Section of Rotary Pump, Type *B*

wheel through a pair of spur gears having a ratio of 5 to 1, and another case where an electric motor was connected to a rotary pump through spur gearing having a ratio of 1 to 5. In each case, the pumps took their suction supply under a head. Both cases may be dismissed as examples of poor engineering, for the requirements of fire service would have been much better served if the two pumps were to exchange places and the reduction gears omitted, thus securing the simplest, cheapest and most reliable arrangement.

The earlier mills were operated almost exclusively by waterwheels and their usual speed made it comparatively easy to connect with rotary pumps. Thus, a great many pumps of this type found their way into the wheel pits of mills, although they were too often, unfortunately, poorly located. Power plunger pumps were used in a few cases, but the rotary came to be

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Abstract of Paper. Presented at the Annual Meeting, 1913, of The American Society of Mechanical Engineers. Pamphlet copies of the complete paper may be obtained: price, 10 cents to members, 20 cents to non-members.

the prevailing pump, owing to its simplicity, cheapness and adaptability to the prevailing power. Where waterwheels of ample power and moderate speed are available, the rotary type of pump becomes the logical choice, for the two can often be direct-connected, or some simple form of transmission, such as friction gears, or a silent chain having a low speed ratio can be employed. The impulse form of waterwheel with its high speed would find a better selection in the centrifu-

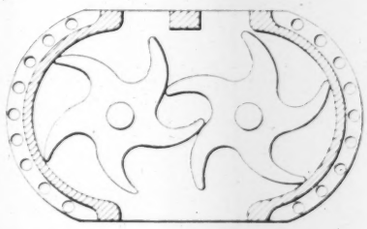

Fig. 2 Working Cams of Rotary Pump, Type *B*

gal pump, requiring no intermediate gearing. In weighing the claims of the several pumps for a situation, three things should be kept in mind: the character of the power available, the limitations of the pump and the fact that the simplest drive is the best.

ROTARY PUMPS

There are so many indifferent rotary pumps in mills and factories that the mere mention of a rotary raises doubts as to its value for fire purposes. Still, it should be remembered that even with the imperfect construction of the old time cast-iron rotary, they have given

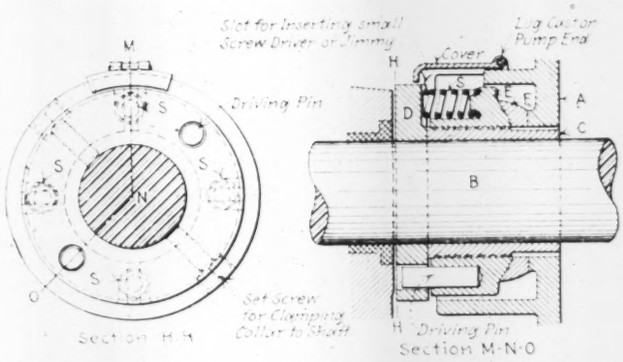

Fig. 3 Water Joint used on Rotary Pump Shafts, Type *B*, as Substitute for Stuffing Box

some very effective service at critical times. However, I invite your attention to that product of the rotary pump builder that meets the present insurance specifications and notably that which is designated as Type *B* (Figs. 1 and 2).

Several features of this design were proposed and developed by the author in 1904. They were not immediately adopted, as some experimental work was necessary, and new patterns were required. These new features were chiefly as follows: In place of the usual two sets of overhung cast-iron gears, one extra-heavy pair of cut steel gears is substituted, preferably forged solid with their shafts; these gears are supported on either side by generous bearings, and the two shafts are larger and stiffer; all bearings are provided with liberal oil reservoirs and ring or chain oilers; in place of the usual stuffing boxes, a special form of metal water joint has been adopted, which is giving excellent service, thereby avoiding the use of perishable packing. The usual fire pump features are also provided; viz., the casing and working parts exposed to corrosion are of bronze; there are more liberal water passages; the working cams are of a new design to insure reasonably smooth running; and the usual air chamber, hose connections, an approved spring relief valve and starting valve complete the arrangement. The press frame carrying the friction gear is now fitted with a heavy spring that maintains the gears in contact, and com-

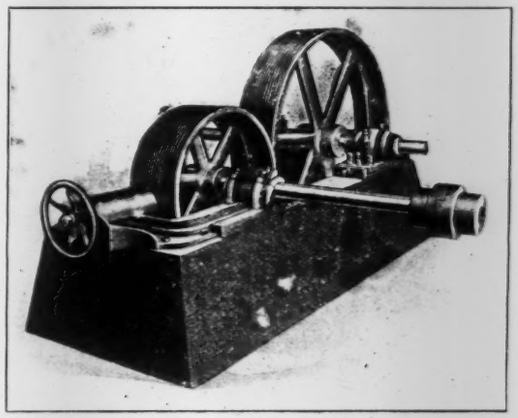

Fig. 4 Typical Press Frame for Friction Gears driving Rotary Pumps

pensates for a possible lack of truth in their running (Fig. 4).

These pumps are not intended for daily service as the wear between cams and casing would soon render them inefficient. But for the brief periods of fire service, considerations of wear are of less importance than certainty of action. Full particulars as to their construction can best be gathered by a study of published specifications. The effort has been to secure a rugged, reliable pump capable of doing hard work, resisting corrosion and withstanding abuse. These pumps are obtainable today from at least two manufacturers, and cost somewhat less than a duplex pump. The limited number that are already in the field are so far giving excellent satisfaction.

DUPLEX PUMPS

Where steam is the most reliable source of power, the duplex Underwriter pump is usually the choice, because of its record of proved value. It is also much the cheapest of any steam-driven fire pump of accept-

able reliability, selling for approximately ten cents a pound. In spite of its numerous parts, liable to derangement, this pump has been so thoroughly boiled down, so to speak, that with present day construction it is proving to be one of the most reliable of fire protection appliances. The steam-turbine driven centrifugal pump is, of course, available for those who are willing to pay the price, but it costs approximately

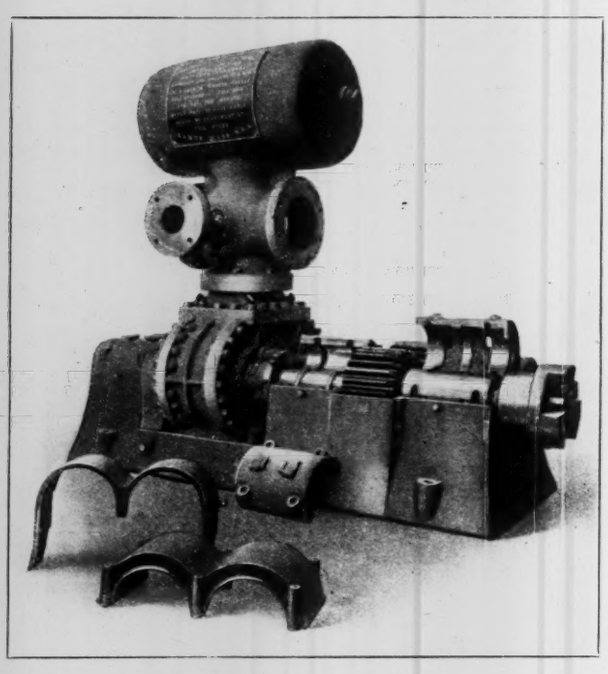

Fig. 5 Rotary Pump, Type *B*, Partly Dismantled

twice as much. Its main advantage over the duplex is its simplicity of working parts. Its disadvantages lie in the fact that a pressure of 100 to 125 lb. of steam is required for good results, whereas, with a duplex pump, 50 lb. of steam is ample for ordinary fire pressures. The outfit is also subject to the same limitations as to suction lift as all centrifugal pumps. When the steam turbine centrifugal has become standardized and its price made more nearly competitive with that of the duplex, no doubt it will receive a much wider introduction.

As steam began to supplement and in cases to supplant water power in mills, steam-driven pumps were installed to help out or replace the rotary. At first the single cylinder pump was used, but the advent of the duplex pump marked the beginning of a better machine for fire purposes. The duplex type of fire pump is so well known that it is hardly necessary to describe it, full information as to construction being available in published specifications. When the development of the Underwriter type of duplex pump was undertaken by Mr. John R. Freeman in the early nineties, he found the pump as made for the trade lacking in several features needed for fire protection. The frequent failures in the field showed mainly that improvement was needed. Pump builders did not fully sense the importance of some of the features that were demanded, and more or less opposition was encountered.

The old trade duplex pumps were found with steam and water passages restricted, but these have been enlarged in the Underwriter type, and a higher speed thus made possible. The trade pumps were iron fitted and became rusted through neglect, so that they could not be started; the Underwriter pump is brass fitted wherever corrosion is liable to seize the working parts. In the older pumps, cast-bronze valve stems were used that worked loose or broke off; in the present Underwriter standard, these stems are of rolled bronze and made heavier, and the guard and nut are so secured in place by a lock devised by the author that the parts cannot work loose (see Fig. 7). In the old trade pump it was common practice to provide means of adjustment for the valve motion, and this adjustment sometimes worked loose, or was tampered with, putting the pump in a lame condition; in the Underwriter design, all adjustment has been ruled out and a simpler and more reliable mechanism is now used. Special fire serv-

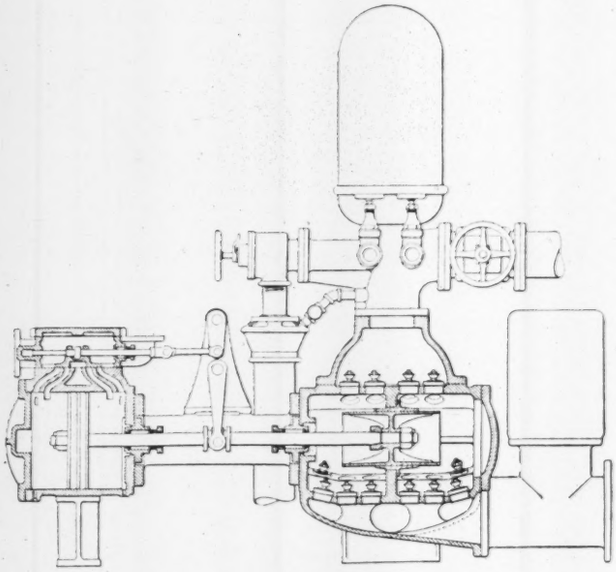

Fig. 6 Sectional View of Underwriter Steam Fire Pump

ice fittings are attached, such as priming valves, starting valve, relief valve, hose valves, oil pump and lubricator, all these parts having been subjected to examination and test before adoption. (See Fig. 6.)

To incorporate these changes has taken time and it has been more or less an up-hill job. Experience, however, has shown the value of these improvements and has indicated from time to time still further improvements which have been adopted, so that today we have a fire pump that is able to start at a moment's notice, run at full speed if needed, and when supplied with steam, water and oil, will run continuously and deliver

its rated capacity, or more, against a fire pressure of 75, 100, 150, or even 200 lb. in special cases.

ELECTRICALLY DRIVEN PUMPS.

Where the electric motor is the most reliable source of power, the centrifugal pump naturally becomes the choice. The speed of a centrifugal pump can readily be made to conform to the speed of the standard motor

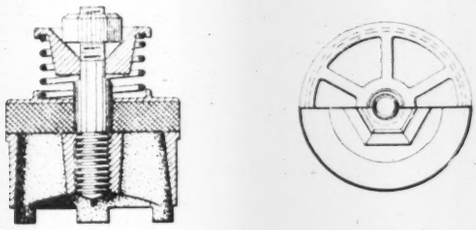

Fig. 7 Detail of Valve Stem and Special Nut-Lock

and all intermediate gearing avoided. The direct-connected motor and pump thus form the simplest possible arrangement. It has, however, certain limitations which will be noted later, and there may exist conditions which some form of power pump electrically driven would meet with better satisfaction.

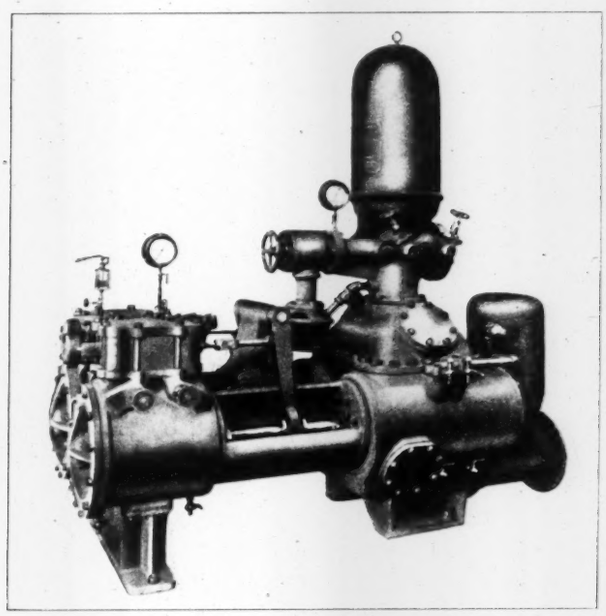

Fig. 8 General View of Underwriter Steam Fire Pump

Comparatively few power pumps are in use as fire pumps, owing to their higher cost. Their best field is where a daily service pump of good efficiency is needed, that can in the emergency be used for fire purposes. The triplex type of power pump is much to be preferred to the single or duplex forms, owing to its steadier discharge pressure, and as it is usually built in the vertical form the floor space required is the minimum. A strong point in favor of the triplex power pump as compared with a centrifugal is its higher efficiency, running as high as 80 to 85 per cent for outside packed plungers as against the usual 65 to 70 per cent for the centrifugal. That type of triplex pump employing one centrally located driving gear is much to be preferred to those having two overhung gears. Experience has shown that the central gear drive will better ensure an even distribution of power, and thus avoid undesirable stresses on gear teeth and possible breakage. A notable example of the central gear triplex power pump may be found in the high-pressure fire service station in Philadelphia, where seven such pumps are operated by gas engines, and

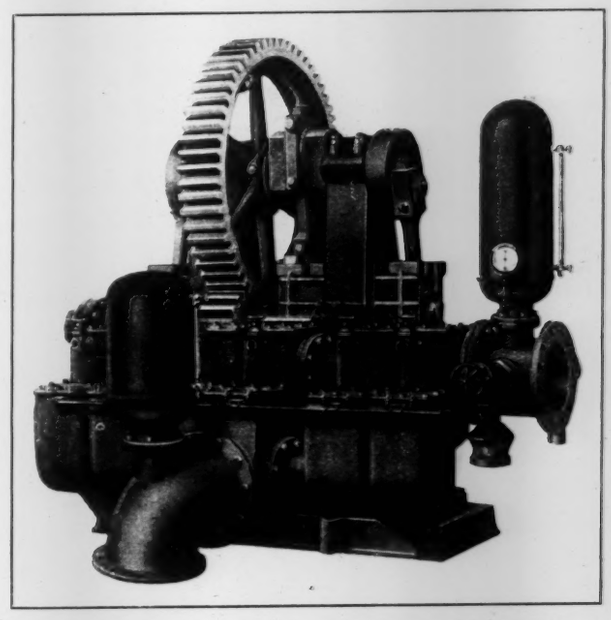

Fig. 9 View of Triplex Power Fire Pump

have given excellent satisfaction with a minimum of repairs.

The centrifugal pump is comparatively a newcomer in the fire pump field. It is distinguished from all others in being a *velocity* pump, the pressure varying directly as the square of the peripheral velocity of the impeller. The electric motor is no doubt responsible for its coming so rapidly into favor. The constant speed motor direct-connected to the pump makes the simplest and cheapest arrangement and affords a fairly wide range of capacities and pressures. The variable speed motor or steam turbine, costing a little more, would place the pump more nearly on a par with the steam duplex as to range of pressures, and, the author believes, would make the preferable outfit. Its greater cost, and complication is the general objection to it.

There are two types of centrifugal fire pumps built, one with the simple cylindrical case, known as the volute pump, and the other with a diffusion vane casing or chute case. The diffusion vane type, sometimes

called the turbine pump, employs a series of gradually enlarging passages that permit a more gradual change of the velocity of the water into pressure than does the volute, thus resulting in some slight gain in efficiency. This, however, is not an essential part of an acceptable fire pump, and as the volute type of pump is much simpler in construction, and yields efficiencies that are satisfactory (60 to 70 per cent), this type of centrifugal fire pump is being generally adopted. This type also lends itself better to the horizontal division of casing, which is preferred to the circumferential division, as it permits quicker and better access to the interior for overhauling or cleaning.

The simplicity of the centrifugal, having but one moving part, appeals to every engineer. There are no valves to choke up, no plunger to wear out, no valve motion or gears to break, and no dangerous pressures possible even with all outlets closed, unless specially provided with a variable-speed prime mover. The discharge is steady, smooth, devoid of shocks, and more nearly approximates that from a gravity supply than any other pump. But it has its limitations, which should be fully realized and considered in making an installation. Unless provision is specially made for a variable speed, its maximum working pressure is usually not planned to be very much above 100 lb. pressure, running for the smaller flows in some cases up to 130 or 140 lb. Consequently the water pressure needs of a situation should be carefully studied before deciding on this form of pumping outfit, and if higher pressures are needed, either a special form of impeller should be substituted or a variable speed provided.

A centrifugal has no power to exhaust the air from a suction pipe, as has the rotary, duplex, or other displacement pump. For this reason, the suction supply should come to the pump under enough head to flood the pump casing, thus insuring its being primed. If a lift is unavoidable, then it becomes necessary to provide a suitable foot valve and a generous supply of priming water, enough to fill completely the suction pipe and pump casing. This feature, of course, limits the centrifugal to situations where there are easy suction supply conditions.

In cost the centrifugal pump with bedplate is but little more than the duplex per pound, but the addition of driving motor brings up the price very materially, so that the outfit combined costs 15 to 16 cents per lb., and weighs about the same as a duplex pump. For a given type, the speed of a motor determines its size and influences the total price of outfit. It may roughly be stated that the centrifugal pump and motor costs 50 per cent more than the duplex. There is a wide difference, however, in the weights of the same size pump among different manufacturers.

INSTALLATION

The success or failure of a fire pump depends very much on its being properly erected and connected up. Briefly, it may be said that a fire pump must be so located as to be safe at all times from the breakage of its pipe connections due to the falling of floors and machinery, and safeguarded from any influence such as smoke, fire or flood that might drive away the operator. It should be accessible at all times for operating and overhauling, and not blockaded by miscellaneous storage. It must permit of practicable pipe connections, the suction pipe receiving first consideration, and the steam and discharge pipes so run as to be safe from damage and always be in commission. The exhaust should go direct to atmosphere, and not be tied up with other pipes.

The suction supply should preferably be practically inexhaustible, such as a river or lake, and a suitable intake, properly screened, provided. Where a stored supply only is available, it should be large enough to supply the pump for two hours, more or less, depending on conditions. No cast-iron rules can well be established as the insurance engineer having jurisdiction is expected to weigh conditions, and secure a reliable pump service without expensive or complicated refinements. Full details as to pump installation have been covered in the several publications and specifications

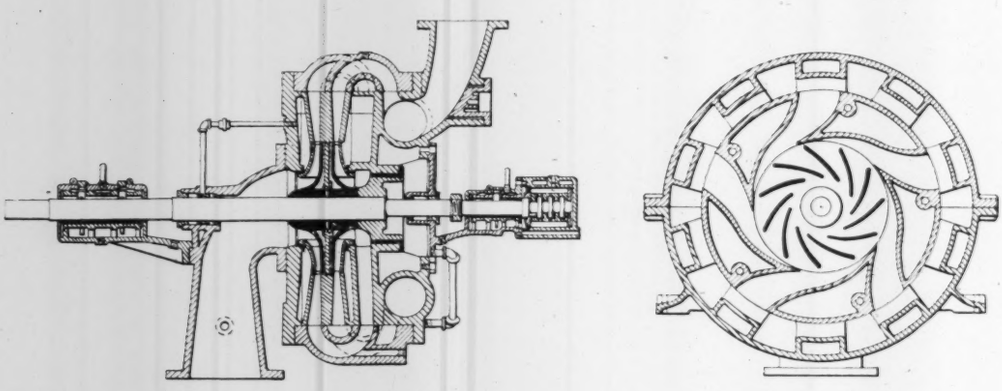

Fig. 10 Centrifugal Fire Pump with Diffusion Vanes

which from time to time have been developed in the Factory Mutual Inspection Department.

It will perhaps be of interest, and not altogether without value, to look a bit into the future and try to discern what is to be the development of the fire pump. It is not at all unlikely that the steam turbine centrifugal will gradually displace the duplex pump, as its design becomes simplified and standardized, and its cost lowered. Where steam is not available, we shall find the electric-driven centrifugal, or the gasolene driven rotary, and as fast as its development permits, the gas-turbine driven centrifugal will possibly win recognition and receive adoption. To whatever extent insurance interests adopt these new appliances, it will be done with an eye single to their proved value, as regards simple and rugged construction and reliability of performance.

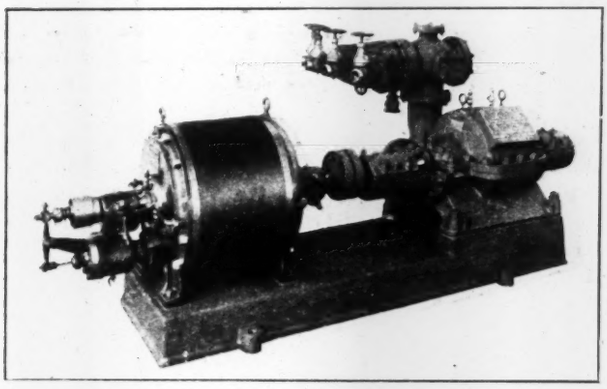

Fig. 11 Example of Steam Turbine Driven Centrifugal Fire Pump Unit

DISCUSSION

Alfred B. Carhart. Upon the practical side of the operation of fire pumps, I think the author of this paper has called attention, in one of the final paragraphs on Installation, to a very important consideration, which was not mentioned in the presentation of the paper. It is such a simple matter, that it seems surprising that engineers in laying out new plants, will connect the exhaust of steam-operated fire pumps with other exhaust lines, and then supply stop valves by which these pipes can be cut off from the exhaust line to prevent back-pressure and condensation, not realizing that when the fire pump is needed in a hurry, it will be impossible to operate it effectively, because there will be no free outlet for the exhaust steam. Such conditions have been discovered, much to the chagrin of those in charge of otherwise admirably constructed plants.

A. Blauvelt (written). Referring to the section of Mr. Clark's paper on electrically driven pumps, it is my observation in the field that the electric motor centrifugal pump is as yet considerably short of working development as compared to the Underwriters steam fire pump. The steam pump is a self-contained affair including the more essential fittings, and ordinarily is handled successfully when needed. The electrically driven pump thus far appears always to require considerably more skill and sense of time on the part of the operator. The motors are excellent and so are the pumps, but neither pump maker nor motor maker appears to know each other, nor do either appear prepared to deliver a complete pumping set, fully fitted and adapted to unfamiliar and incompetent handling in a degree comparable to the steam pump. Meantime, mismoves, or delay or total failure of starting, mark the attempt of watchmen or other men not trained to the electric pump. I take no pride in the various electric pumps installed in our practice thus far, and have less esteem for similar jobs set up under other auspices. Doubtless as the trade increases some shop will put out a complete and self-contained electric pump, with fittings interlocked or timed against mismoves.

The Author. From the remarks of Mr. Blauvelt, it appears that he finds that men not trained to the electric pump make mismoves, or totally fail to start the pump. This is also true of men not trained to steam or rotary pumps.

It should be remembered that the steam fire pump has been growing up with us for 40 or 50 years, and there is a larger number of average men familiar with such apparatus than there is familiar with the electrically driven centrifugal pump. The latter has been with us but a few years, and for the average man it is still somewhat of a novelty that he but vaguely comprehends.

A remedy for this situation does not appear to be getting the pump maker to know better the motor maker. It is rather for the pump operator to know better the apparatus under his charge. It has not been found necessary for rotary pump builders to furnish the waterwheel driving the pump, nor has it been necessary for steam pump makers to go into the steam boiler business.

The troubles arising from centrifugal outfits are mainly due to errors in installation, or a failure to realize the limitations as well as the possibilities of this type of pump.

A properly installed centrifugal and motor is one of the simplest of fire pumps, and easy to start. Regarding interlocking devices to prevent mismoves, these are but complications that add to the confusion of the operator. A simple device under intelligent control is much to be preferred to automatic control involving added complications. It is not necessary for a man to be an electrician in order to operate a motor driven centrifugal, any more than it is necessary for a steam pump operator to be an expert in hydraulics, pneumatics, and the use of steam. But he does need to know something about these matters in either case, and especially to know the use of the fittings and devices that he sees before him. There is no positively certain way to prevent an incompetent man from making the fool move.

There will no doubt be improvements made from time to time based on experience tending to standardize these outfits, which will simplify their operation; but the lack of confidence in present apparatus which is expressed by the gentleman is not shared by the author.

NECROLOGY

GEORGE WESTINGHOUSE

George Westinghouse, Past-President and Honorary Member of the Society, died in New York on March 12, after an illness of several months. He was born at Central Bridge, N. Y., October 6, 1846. A few years later his father, who was a manufacturer of agricultural machinery, moved to Schenectady, where the boy attended the public schools and outside of school hours and during vacations studied mechanics and learned to handle machinery at his father's shop.

When the Civil War came on the patriotic ardor which filled the youth of the country drew young Westinghouse into the volunteer army. Although he was under the age for enlistment, his size and strength were such that he was admitted to the service, first joining the cavalry. In December 1864 he became an assistant engineer in the navy, serving in that capacity until August 1865.

After the war he returned to Schenectady and entered Union College, but this was a classical institution and the bent of young Westinghouse was in the direction of mathematics and engineering. Acting upon the advice of the president of the college, who felt that such latent ability should be given an unrestricted opportunity for growth, he left before graduation and started seriously upon his career in engineering.

Putting the president's advice into practice, he took out his first patent. He had seen a crew of railroad men tediously working to replace a derailed car on the tracks and thought their primitive methods were wasting time. He invented a simple device for the operation and undertook to sell it to the railroads.

On one of his journeys "frog selling," as he has called it, he was close to a collision of trains. The brakemen, tugging at their handbrake wheels, did their best, but the best of handbrakes were primitive affairs, and in emergencies almost useless. He conceived the idea of instantly braking an entire train with some form of power apparatus controlled by the locomotive engineer. In a year or so, after much experiment, he was satisfied that he had made a practical design, but he was without capital to manufacture the equipment of even a single train and to get the invention tried. He went to Pittsburgh, where he obtained encouragement enough to begin in a small way. He patented the air brake in 1867.

The first train to which this brake was applied ran on a line west from Pittsburgh and on what is now a portion of the Pennsylvania Railroad. During the trial trip a collision with a loaded team stuck on a grade crossing was prevented. This practical illustration of the utility of the invention led to the adoption of the brake. Mr. Westinghouse, retaining the control of his invention, undertook to manufacture it and organized the Westinghouse Air Brake Company, establishing at Pittsburgh the business which subsequently became the nucleus of the many industries associated with his name. He later applied compressed air to switching and signalling and utilized electricity in this connection. From this grew the Union Switch and Signal Company.

His introduction of electricity into switch and signal work led him far into electrical experiment and he devoted his energies to a cause in which few then believed, the adoption of the alternating current for lighting and power, in which he had to meet and overcome almost fanatical opposition, which in many states sought legislation against the use of the alternating current as dangerous to the public welfare. In 1885 he acquired the patents of Gaulard & Gibbs, and having undertaken a comprehensive study of the distribution and utilization of electrical currents in a large way, he personally devised apparatus and methods for the work, and gathered around him a group of men who were to become experts in the new electrical art. He also organized the electrical company which bears his name and undertook the development and manufacture of the induction motor which made practical the utilization of the alternating current for power purposes.

The Westinghouse Machine Company was established by Mr. Westinghouse in the 80's for the manufacture of high-speed steam engines, and at this plant has come in succession the construction of large steam engines, gas engines and steam turbines.

Following the discovery of natural gas in the Pittsburgh region, Mr. Westinghouse devised a system for controlling the flow and for conveying the gas over long distances through pipe lines, thus supplying fuel to the homes and factories of Pittsburgh. He took up the study of the gas engine, and for ten years conducted a series of exhaustive experiments in this line, at the end of that time putting into commercial use a gas engine of large power for electric generating.

Mr. Westinghouse introduced the Parsons steam-turbine into this country, adding to it improvements and developments of his own, and others carried out under his supervision. The reduction gearing for driving the propeller shaft of a ship by means of a steam turbine was developed at the Machine company's works, with the coöperation of the late Admiral Melville and John H. Macalpine. Very recently, also, the Westinghouse air spring for motor vehicles was brought out.

It is impracticable to enumerate here the inventions which Mr. Westinghouse had personally made or those which his staff have brought forth under his supervision. As a result of this work and enterprise, there have grown thirty corporations of which he was president at one time, employing 50,000 men, with works at Wilmerding, East Pittsburgh, Swissvale and Trafford City, Pa.; at Hamilton, Canada; London and Manchester, England; Havre, France; Vardo, Italy; and at Vienna and St. Petersburg.

Mr. Westinghouse made many visits to Europe in connection with his inventions and industries. There as in his own country he won the friendship of the foremost men of his time and the high esteem of the engineering profession. He has been decorated by the French Republic and by the sovereigns of Italy and Belgium; and he was the second recipient of the John Fritz Medal "for the invention and development of the air-brake," Lord Kelvin, his friend of many years, having been the first. The Königliche Technische Hochschule of Berlin bestowed upon him the degree of Doctor of Engineering; and his own college, Union, gave him the degree of Ph.D. The Edison Gold Medal was presented to him in 1912 for his "meritorious achievement in connection with the development of the alternating system for light and power." In 1913 the Grashof Medal of the Verein deutscher Ingenieure, the highest honor in the gift of the engineering profession of Germany, was awarded to Mr. Westinghouse on the occasion of the official visit to Germany of the American Society of Mechanical Engineers, and ac-

companying the medal was a certificate which read: "To George Westinghouse, who opened up new fields by his invention of the automatic railway brake, successfully fought for the introduction of the alternating current in the United States, and did useful work in the designing of high speed machinery."

Besides his honorary membership in The American Society of Mechanical Engineers, Mr. Westinghouse was one of the two honorary members of the American Association for the Advancement of Science and an honorary member of the National Electric Light Association. Mr. Westinghouse was two months under 21 when he married Marguerite Erskine Walker, who with a son, George Westinghouse, Jr., survives him. She was his sympathetic and understanding companion throughout his whole career.

MEETINGS

ATLANTA, FEBRUARY 18

A meeting of the affiliated technical societies of the city of Atlanta was held at the Carnegie Library of that city on February 18. The Engineering Association of the South acted as the hosts of the occasion, W. A. Hansell, Jr., President, presiding. Each of the organizations was well represented.

C. E. Kaufman, in charge of bridges and buildings in the department of the chief of construction of the city, and a member of the Engineering Association of the South, presented a paper on The Plaza over the Railroads in Atlanta's Business Center, with a number of explanatory drawings and details of grades, etc. The cost of the scheme was estimated by Mr. Kaufman at $1,714,000.

General discussion was entered into freely by representatives of all of the organizations. Mr. Haralson Bleckley of the American Institute of Architects, the originator of the idea of the plaza, gave a very interesting talk from the artistic standpoint.

BUFFALO, FEBRUARY 26

At a meeting in Buffalo on February 26 in the University Club of that city, an informal dinner preceded the business of the evening. James Hartness, president of the Society, spoke on the Human Factor in Management, upon which he is an authority, dwelling principally on the necessity for recognizing that habit is one of the natural characteristics of one's nature and that we should take advantage of it in any scheme for organization.

He was followed by Calvin W. Rice, Secretary, who spoke of the work of the Society and its extension throughout the country in the local meetings, with the object of serving the members, who should in turn make it their aim to serve the Society and through it the profession. He also spoke of the service which the library is rendering to members at a distance through its staff of searchers and its bibliographies.

BOSTON, MARCH 4

The annual dinner of the engineering societies of Boston was held on March 4, at the Boston City Club, the presidents of the national engineering societies being the guests of honor.

Guy E. Tripp gave the principal address of the evening on the National Government and Business, in which he said he could not attempt in a short address to cover all the points involved in the legislation now before Congress, affecting the operation of public service corporations, and urged every engineer to secure copies of these bills and acquaint himself with their features. He defended American business interests, as involving sane or fair competition.

He was followed by Dr. A. E. Kennelly, vice-president of the American Institute of Electrical Engineers, who spoke on the work of the I.E.C.; and by C. O. Mailloux, president of the American Institute of Electrical Engineers, who emphasized Dr. Kennelly's work in the standardization of the nomenclature of the electrical field.

James Hartness, president of the Society, spoke of the industrial progress in Germany and of the encouragement of legitimate business in America.

The closing address was made by Dr. M. W. Franklin, of the Sprague Works, General Electric Company, on Ozone Applied to Ventilation.

BOSTON, MARCH 11

The March meeting of the Society, held at the Wentworth Institute on South Huntington Avenue, on March 11, was a symposium on welding topics. The purpose of the meeting was to bring out the advantages of welding over other methods of repair, and the possibilities of resorting to such means in place of renewal of parts; also to show to what particular fields of industry or classes of work the several methods of welding may have special adaptation. The various welding methods were individually treated as follows: Oil furnace methods by W. N. Best, consulting engineer on oil furnaces and oil heating, New York; electric welding processes by the Thompson Electric Welding Co., Lynn, Mass.; oxy-acetylene welding, by Henry Cave, president of the Autogenous Welding Co. of Boston, and thermit welding by W. R. Hurlburt of the Goldsmith Thermit Co. of New York. The methods were illustrated by lantern slides and by practical demonstrations.

NEW YORK, MARCH 10

A joint meeting was held by the Society on March 10 with the American Institute of Mining Engineers and the American Electro-Chemical Society, on the subject of Color Photography. There was a large audience and many beautiful slides were shown of colored transparencies made by the several different processes now used in color photography.

The first speaker was Mr. F. E. Ives, whose pioneer work in photography and half-tone engraving is well known. He said that in 1888 he had given demonstrations upon the screen of color transparencies which had created a profound sensation, and in 1889 had prepared colored slides to illustrate lectures on Yellowstone Park, etc., at the Franklin Institute and elsewhere. The public, however, demanded colored prints on paper. He exhibited at this meeting, for the first time, some of the results of new processes of his own which made color photography on paper practical in the hands both of professional and amateur photographers. The first requirement in trichromatic process photography is a camera which will make at one exposure three separate negatives to represent the three primary subtractive colors. He exhibited a camera for this purpose known as the "tripak," about the size of an old style box kodak, which employs a plate pack from which the name of the camera is taken. The pack is used in a single plate holder and handled as a unit

until the negatives are developed and fixed. The three plates are exposed respectively through orange-red, green and violet-blue screens. After developing and fixing, three separate prints are made on a transparent film coated with bichromated gelatine. The exposed film is then developed in hot water, making a gelatine relief print, the three images of which are immersed in their respective dye baths: peacock blue for the negative made with the red light; magenta pink for the negative made with the green light, and yellow for the negative made with the blue light. The transparent prints are then superimposed and cemented together, giving a reproduction of the colors actually existing in the subject photographed.

The Lumiere process was described by Westley Allison. The glass plate to be used is first covered by a mixture of minute starch particles dyed orange-red, green and violet-blue, equally distributed over the surface and filled in with lamp black, after which a coating of panchromatic emulsion is applied. The plate is exposed in the camera with the glass side toward the lens, producing a negative, which is affected according to the amount and quality of light transmitted through the colored grains. The negative is developed, but before fixing is treated with a permanganate of potash solution which converts it into a positive. The varying density of this positive in connection with the colored grains produces the desired colored effects when the plate is held to the light.

C. W. Robinson spoke of the Joly, Macdonough and the Powrie-Warner processes. In all of these processes a screen ruled with parallel red, green and blue lines is interposed between the lens and the sensitized plate; or the screen may be made a part of the plate. The lines on these screens are produced on successive coatings of bichromated emulsion by exposure through a ruled grating and each set of lines is colored by dyeing. In the early Macdonough process, however, the lines were ruled by hand and were made as fine as 300 to the inch, but in the Powrie process the lines were ruled photographically and 3000 lines to the inch are easily obtained. In the Powrie process it is not necessary to adjust the transparency to the screen as in the other ruled or mosaic screen plate processes because the screen can be placed at right angles to the position it was in at the time the plate was exposed and produce good results, on account of the finely ruled lines. He said that Mr. John H. Powrie and Miss Florence M. Warner, both Americans, had worked exclusively on the development of this process for the past eighteen years.

George F. Clifton showed beautiful slides made by the Paget mosaic process. In this as in the Joly, Macdonough or Powrie system, a colored screen is used when exposing the negative, but in the form of a mosaic composed of colored particles, hexagonal in shape, which fit closely together and are more transparent than the starch and lamp black grains of the Lumiere process.

The meeting concluded with remarks by John B. Taylor, Dr. U. S. Kahn and Henry Hess.

Mr. Taylor, who is an amateur photographer, showed a number of slides; Mr. Kahn referred to a new paper called Utocolor, a color paper made abroad, which had lately been introduced in America, permitting the printing of colored pictures directly from a properly exposed autochrome plate; Mr. Hess spoke briefly of his interest in color photography, and especially of his interest in forwarding the work so successfully done by Mr. Ives in producing colored paper prints, and the standardization of the process to bring it within the capacity of the amateur.

CHICAGO, MARCH 18

A banquet was held in Chicago on March 18, at which 225 members and guests were present. Large Steam Power Plants was the subject of the evening, a number of prominent engineers having been invited to discuss the various phases of present day operation and suggest improvements for the future. W. B. Jackson acted as toastmaster.

I. E. Moultrop was the first speaker of the evening, and preceded his technical address with a short talk on the work of the Society, especially as related to the increase of membership campaign. He called attention to the great importance of the boiler room and where the most intelligent supervision wae required, and said that there was a lack of suitable CO_2 recorders, steam meters, draft gage, etc.

J. W. Parker spoke at some length on boiler operation, explaining instances that decided in favor of a large unit. He believed this would work out for better results in the operation of the boiler room, and said that the limit of size had not yet been reached. A very large boiler is not any more difficult to take care of or more expensive to operate than the standard size equipment of such apparatus.

John Hunter stated that he had practically just "come on shore" from marine work. He told of placing wooden patches on the boilers he operated while in the maritime service, and explained in detail how the Missouri Light and Power Plant is operated in parallel with the Keokuk Hydro-Electric Plant, from which 60,000-kw-hr. service is taken.

W. L. Abbott closed the discussion with a talk in which he related his many interesting experiences as chief operating engineer of the largest power plants in the world. He argued for a reduction in the number and size of chimneys, with a corresponding increase in the number of forced draft installations; also for a further reduction of the flue gas temperature by applying the gas to the feedwater system of the plant to a much greater extent than is found in present practice.

PHILADELPHIA, MARCH 14

A meeting of the Society with the Engineers Club of Philadelphia was held in Philadelphia on March 14 and was preceded by the brief transaction of business.

I. E. Moultrop gave the paper of the evening upon Steam Power Plants, which covered a very wide field. Mr. Moultrop described the location and general arrangement of the various plans, facilities for receiving, storing and handling coal, the supply of condensing water, the relative position of boilers, prime movers, switchboards, etc., and the architectural features of the buildings, both exterior and interior. He laid special stress on the importance of better economy in the boiler room and advocated the employment of men of the same grade of intelligence as skilled mechanics and the furnishing of apparatus to indicate the conditions under which the fuel is being burned. The increasing importance of pure feedwater was also pointed out.

The paper was discussed by Wm. Eglin, A. C. Wood, W. C. Kerr, and Mr. McFarren.

TESTS UPON THE TRANSMISSION OF HEAT IN VACUUM EVAPORATORS

BY E. W. KERR, BATON ROUGE, LA.

Member of the Society

THIS paper deals with a series of tests made at the laboratories of the Louisiana State University to determine the effect of hydrostatic head, density of heating steam, incondensable gases in the heating steam, density of the liquid being boiled, design of the heating compartment, etc., upon the transmission of heat in vacuum evaporators of the kind used in the sugar and other industries.

After making a number of tests on multiple evaporators in sugar factories it was concluded that a special experimental plant would have to be constructed for testing purposes, in order to control the conditions of operation. Accordingly, an apparatus was designed and built in the mechanical laboratory of the Louisiana State University and Audubon Sugar School, and, although considerably smaller than the average commercial machine, was large enough to give results comparable with what might be obtained from units of commercial size.

Five different designs of heating compartments varying as regards tube dimensions, tube arrangement, circulation of juice, steam distribution and manner of removing incondensable gases were tested. As it is very difficult to control conditions in the different bodies of a multiple evaporator, it was decided to use an evaporator with a single body so constructed that the conditions existing in any of the bodies of a multiple evaporator could be reproduced. With this in view the apparatus was so designed that it was possible to change the type of heating compartment and to control at will the pressure of the heating steam, the vacuum under which boiling takes place, the quality of the steam, the amount of air in the heating steam, and the density of the liquid.

The five calandrias tested differ from each other in several fundamental features. Most important among these differences of design may be mentioned proportions of tubes, that is, ratio of length to diameter; the use or non-use of downtakes to aid the circulation of the juice, and the methods employed for removing incondensable gases. What appears to be more or less conclusive data bearing upon the relative merits of these different designs were obtained in the tests. This is probably brought out best in the hydrostatic tests, Fig. 7, also in the temperature level tests, Fig. 8. Both of these sets of curves, however, show the effects of difference of design only in the rough for the reason that the conditions of operation were not the same in all of the tests. In the case of the temperature level tests there was considerable variation in the hy-

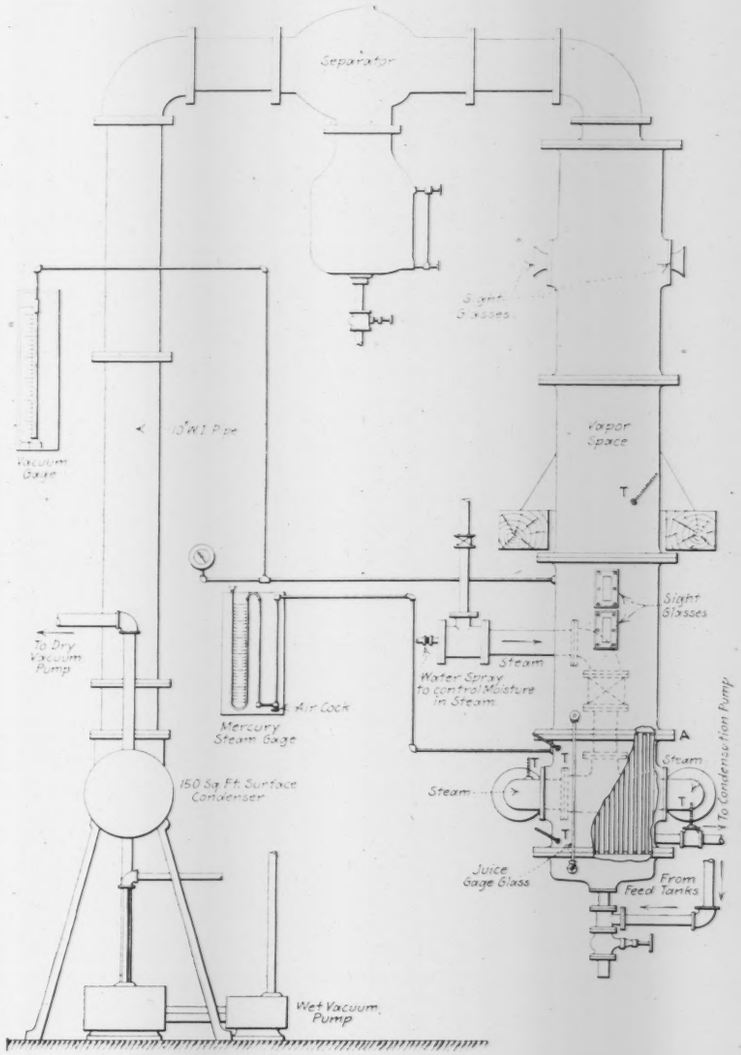

FIG. 1 GENERAL ARRANGEMENT OF EXPERIMENTAL VACUUM EVAPORATOR

Abstract of paper. Published in complete form in the October 1913 issue of The Journal of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Pamphlet copies may be obtained: price, 15 cents to members and 30 cents to non-members.

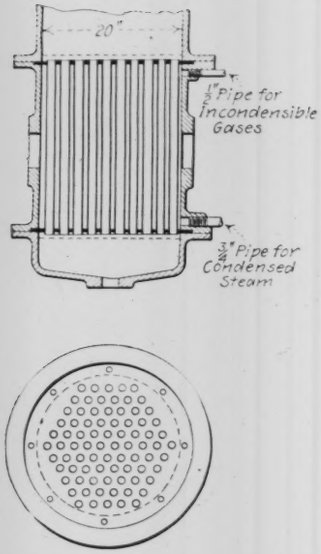

Fig. 2 Calandria A, 80 Copper Tubes 1⅜ In. by 24 In. by No. 18 B.W.G.

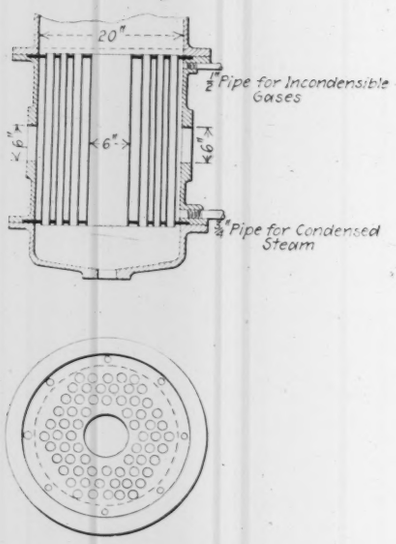

Fig. 3 Calandria B, 66 Copper Tubes 1⅜ In. by 24 In. by No. 18 B.W.G.; 6 In. Downtake; Tube Plates $\frac{3}{16}$ In. Copper

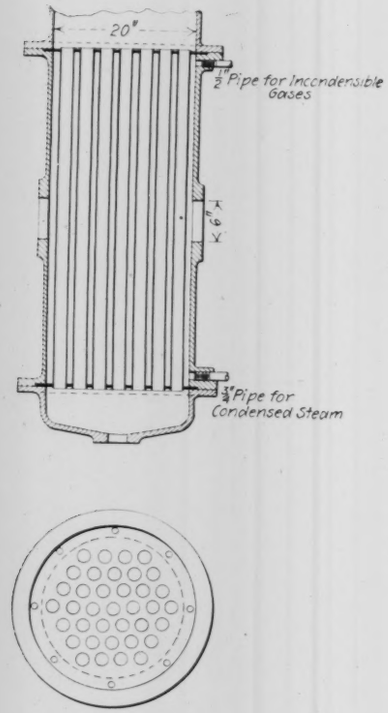

Fig. 4 Calandria C, 37 Copper Tubes 2 In. by 48 In. by No. 18 B.W.G.; Tube Plates $\frac{3}{16}$ In. Copper

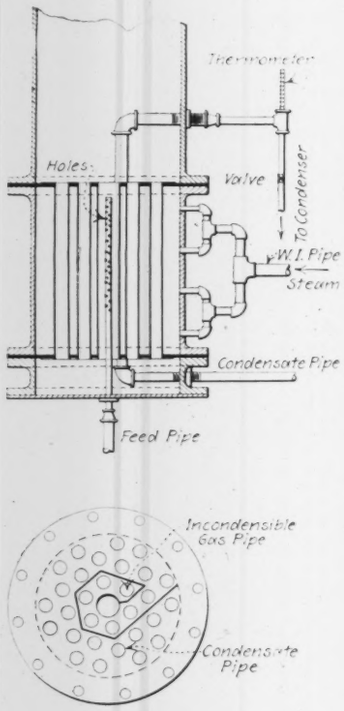

Fig. 5 Calandria E, 30 Copper Heating Tubes 1¾ In. by 24 In. by No. 18 B.W.G.; Total Heating Surface 29 Sq. Ft.

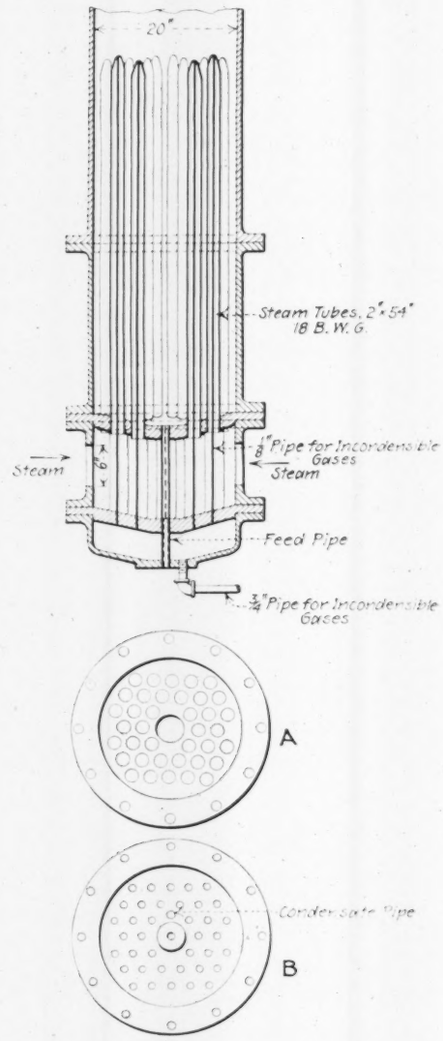

Fig. 6 Calandria D, 38 Copper Heating Tubes 2 In. by 54 In. by No. 18 B.W.G.; Total Heating Surface 86.21 Sq. Ft.

drostatic head. In order to make these tests more nearly comparable the curves of Fig. 8 are reproduced in Fig. 9 with the necessary corrections for hydrostatic head based upon the curves of Fig. 7. The full line curves are taken without change from Fig. 8. The broken line curves are those corrected for hydrostatic head. The principal conditions during the tests are noted on the plat.

Curves 3 and 5 show something as to the effect of varying the proportions of the tubes, the former for tubes 1⅜ in. by 24 in. and the latter for tubes 2 in. by 48 in., some advantage being shown for the long tubes, at least for low temperature levels. The greater heat transmission in the long tubes is probably due to better circulation. The greater the ratio of the length of a tube to its cross-sectional or carrying area, the greater will be the heat transfer per unit of carrying area and this should increase the velocity of circulation.

A comparison of Curves 3 and 4 shows a decided

advantage for the downtake calandria over that without a downtake. The tests on the downtake calandria were made with a hydrostatic head of 16 in., whereas those on the other were made with a 12-in. head. Correction for this difference would slightly increase the advantage shown for the downtake.

Curves 1 and 6 show the results of the tests on two types of evaporators designed especially for efficient removal of incondensable gases. Both show coefficients of heat transmission considerably in excess of those obtained with the standard types represented by Curves 3, 4 and 5. Curve 6 for calandria E, the baffle plate calandria with a head of 12 in., is only slightly higher than Curve 1 which represents D, the double tube calandria with an 18-in. head. These relations are also corroborated in a general way by the curves of Fig. 7. While the good results shown for these two calandrias may undoubtedly be attributed mainly to the more efficient separation of incondensable gases from steam and their removal, it is probable that the increased velocity of steam is also partly responsible.

CONCLUSIONS

The loss in heat transmission due to hydrostatic head is considerably in excess of the theoretical, and this excess is greater for short tubes than for long tubes. The loss with varying heads, other conditions being equal, varies according to a straight line formula.

Other conditions being equal, the lower the "temperature level" the smaller the coefficient of heat transmission; in other words, the lower the temperature and density of the heating steam the smaller the coefficient. The coefficient of heat transmission varies according to the equation

$$U = 2.25 + 17500\,D$$

where D = density of heating steam in pounds per cubic foot.

Air or other incondensable gases in the heating steam greatly reduce the heat transmission, even with relatively low vacua. The coefficient of heat transmission varies according to the equation

$$C\left(\frac{P_s}{P_t}\right)^3$$

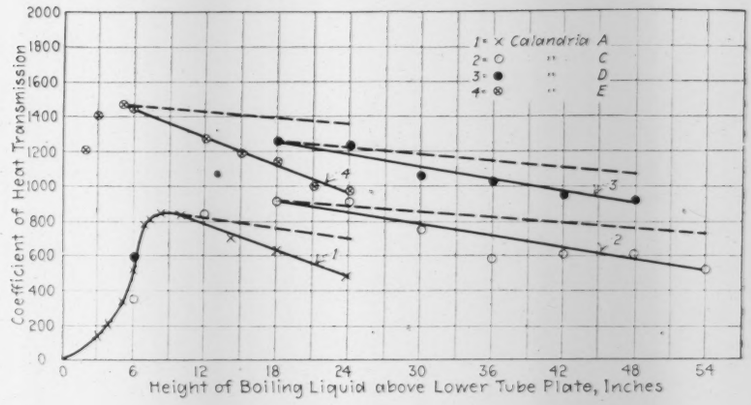

FIG. 7 CURVES SHOWING EFFECT OF HYDROSTATIC HEAD UPON HEAT TRANSMISSION

FULL LINES PLOTTED FROM TEST; BROKEN LINES DRAWN ACCORDING TO CALCULATIONS BASED UPON THEORETICAL LOSS OF TEMPERATURE FALL DUE TO HYDROSTATIC HEAD

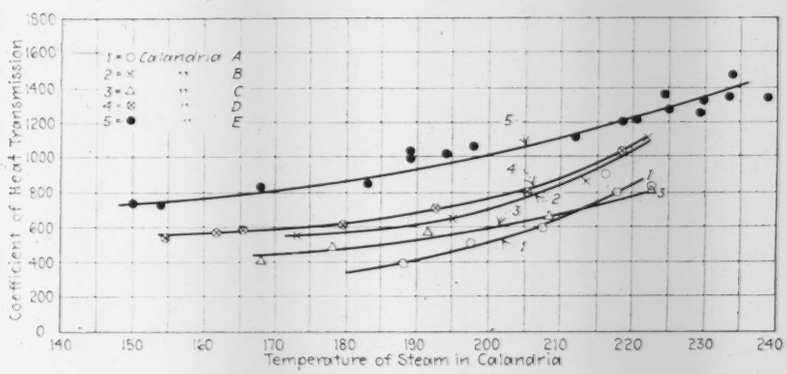

FIG. 8 CURVES SHOWING EFFECT OF TEMPERATURE LEVEL UPON HEAT TRANSMISSION IN FIVE DIFFERENT CALANDRIAS

CURVES PLOTTED FROM TESTS MADE TO DETERMINE THE EFFECT OF VARYING THE TEMPERATURE LEVEL

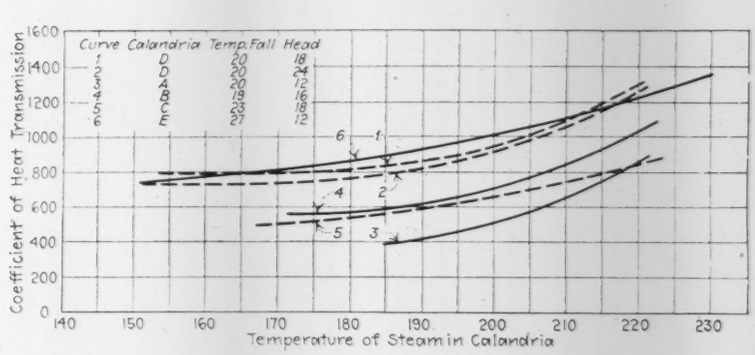

FIG. 9 CURVES COMPARING HEAT TRANSMISSION IN DIFFERENT CALANDRIAS TESTED

FULL LINE CURVES COPIED FROM FIG. 8; BROKEN LINE CURVES SAME AS IN FIG. 8 AFTER CORRECTION FOR HYDROSTATIC HEAD

in which C is a constant, P_s the partial pressure of the steam and P_t the total pressure. The presence of "air pockets" may be conveniently determined by means of thermometers in the steam compartment; good circulation and distribution of steam are important in preventing them.

Increasing the density of the boiling liquid causes a loss in heat transmission due to the decrease in temperature fall. As the density is increased the boiling temperature increases according to the equation $y = CD^{3.1}$, in which C = a constant and D = density in deg. Brix. The total loss due to the density of the boiling liquid seems to be in excess of that due to loss of temperature fall. This is probably due to lower velocity of circulation.

The great temperature fall required in the last body of a multiple evaporator is due to the combined influence of greater amounts of air, steam of lower density, liquid of higher density, also in many cases, more foul heating surfaces, than in preceding bodies.

The downtake or circulation tube was shown to increase heat transmission materially. Long tubes give better results as to heat transmission than short tubes due to better circulation.

The tests show that the double tube and the baffle plate calandrias gave greatly increased heat transmission as compared with the standard types tested, and indicate that attention to steam distribution and the removal of incondensable gases is very important.

DISCUSSION

H. D. Fisher (written). Some years ago the writer had considerable experience with a calandria of the type shown in Fig. 3 of Mr. Kerr's paper. Full details of the apparatus are shown in Fig. 10. It was an experimental apparatus designed for testing out a compression cycle of evaporation, in which the vapor of a boiling liquid was compressed until its saturation temperature was high enough to evaporate a corresponding quantity of the liquid when forced into the steam space of the calandria, at the same time condensing itself. Thus the latent heat of evaporation was never rejected to the condenser as it must be from the last body of a multiple effect, but was used over and over again in the apparatus. A steam coil not shown in the drawing supplied heat lost by radiation and that due to the condensate leaving at a temperature higher than the entering feed though the heat exchange in the lower part of the apparatus returned much of this.

TABLE 1 RESULTS OF TESTS ON FORBES DISTILLING APPARATUS

Test Number	Duration, Hours	Base Pressure Absolute	Compression Pressure Absolute	Temperature of Saturation, Base Pressure	Temperature of Saturation, Compression Pressure	Temperature of Compressor, Discharge	Superheat, Compressor Discharge	Temperature Difference in Calandria	Weight of Water Distilled, lb.	Heat Transfer, B.t.u. per Sq. Ft. per Deg. Difference per Hour	Yield of Water per I.H.P-Hour lb.
1	7.07	32.3	35.1	254.5	259.6	265.5	5.6	5.1	683.0	174	317
2	6.13	32.3	36.6	254.5	261.9	272.9	11.0	7.4	1208.5	245	190
3	3.37	37.5	41.4	263.4	269.4	273.1	3.7	6.0	492.5	222	225
4	3.32	41.6	46.6	269.6	276.6	279.0	2.4	7.0	549.1	214	257
5	4.13	48.0	52.3	278.5	283.9	294.0	10.1	5.4	782.5	316	284
6	3.19	51.0	57.3	282.3	289.7	303.1	13.4	7.4	676.9	258	228
7	3.16	51.9	56.8	283.4	289.2	292.3	3.1	5.8	594.7	291	314
8	3.16	52.2	57.3	283.8	289.7	292.3	2.6	5.9	374.4	181	253
9	3.42	52.4	58.6	284.0	291.2	298.1	6.9	7.2	672.4	245	225
10	3.03	57.0	62.1	289.4	295.0	301.2	6.2	5.6	430.2	227	305
11	2.89	57.0	63.6	289.4	296.5	304.5	8.0	7.1	629.4	274	222
12	3.12	62.1	66.9	295.0	299.9	301.7	1.8	4.9	680.7	395	283
13	3.16	62.2	68.9	295.1	301.9	310.0	8.1	6.8	816.2	339	221
14	3.19	62.8	68.5	295.7	301.5	306.7	5.2	5.8	806.5	388	242
15	3.18	70.8	76.0	303.7	308.5	308.5	0.0	4.8	564.4	327	291
16	3.10	71.3	79.0	304.2	311.2	321.4	10.2	7.0	852.8	349	194
17	3.18	72.1	80.6	305.0	312.6	315.3	2.7	7.6	634.8	232	207
18	3.20	82.1	88.3	313.9	319.0	323.2	4.2	5.1	631.8	340	312
19	3.14	82.3	90.9	314.0	321.0	327.0	6.0	7.0	1024.3	411	264

Steam from the compressor discharge entered through a 2-in. pipe on one side, a little below the middle, and the incondensable gases were vented through a 1/8-in. pet cock at the top and directly opposite. The apparatus was always run at pressures above atmospheric as thermodynamic theory shows an increased economy at higher base pressures, that is, the pressure in the vapor space, and low compressions. This is strikingly borne out by the results in the last column of Table 1, of yield of condensate per i.h.p. hour of compressor. It was found, however, that at low rates of running there was not sufficient velocity in the entering steam to drive the air out from between the small, closely-spaced tubes and it was only when the apparatus was working at a good rate and with denser steam that satisfactory heat transfers in B.t.u. per square foot of surface per degree temperature difference per hour were obtained.

The heating surface was new at the start of the test and examination at the close showed only a slight muddy deposit on the water side and nothing on the steam side. Water levels were carried about 1/4 in. above the upper tube sheet in the vapor space and about 1/8 in. above the lower tube sheet in the steam space.

Compression was apparently practically adiabatic as the

superheats in the steam in the compressor discharge agree quite closely with those calculated from theory, but in all cases the amount of heat represented is negligible compared to the latent heat and it is very doubtful if the superheat has any effect whatever on the rate of transfer.

Mr. Kerr's apparatus is particularly adapted to the elimination of air as he has few large tubes and wide spacings. With commercial designs of calandria even with a steam belt and six or eight contracted openings delivering steam into the tubes at rather high velocities, it is doubtful whether it would be possible to obtain as perfect air venting and as high coefficients of heat transfer as he has done. The ratio of diameter to length of tubes corresponds to the best late practice and should give very satisfactory circulation.

The only criticism the writer has to offer is regarding the length of the tests, as unless steam pressure is very carefully maintained the same at beginning and end, an uncertainty is introduced and with violent ebullition and circulation, it is difficult to be sure a constant water level is maintained inside the apparatus.

A. L. Webre[1] (written). In interpreting the meaning of the results of Prof. Kerr's experiments, several facts must be borne in mind:

(1) The apparatus used was very small as compared with the equipments in practical use today. We know that the relation between a scale model and a full sized unit is problematical. It has been our experience, as a rule, that small vacuum evaporators give much better results than large ones. This is probably due to the more thorough removal of foul gases. It is not practical to obtain a coefficient of transmission greater than 250 in every day work with large units of the types described in the paper as calandrias *A*, *B*, and *C*.

(2) It must also be remembered that the displacement of the condensate pump in his apparatus was many times larger in proportion to the surface in operation than in actual practice. On a 3000 sq. ft. body, it is customary to use a 12 in. single cylinder pump with a piston speed of

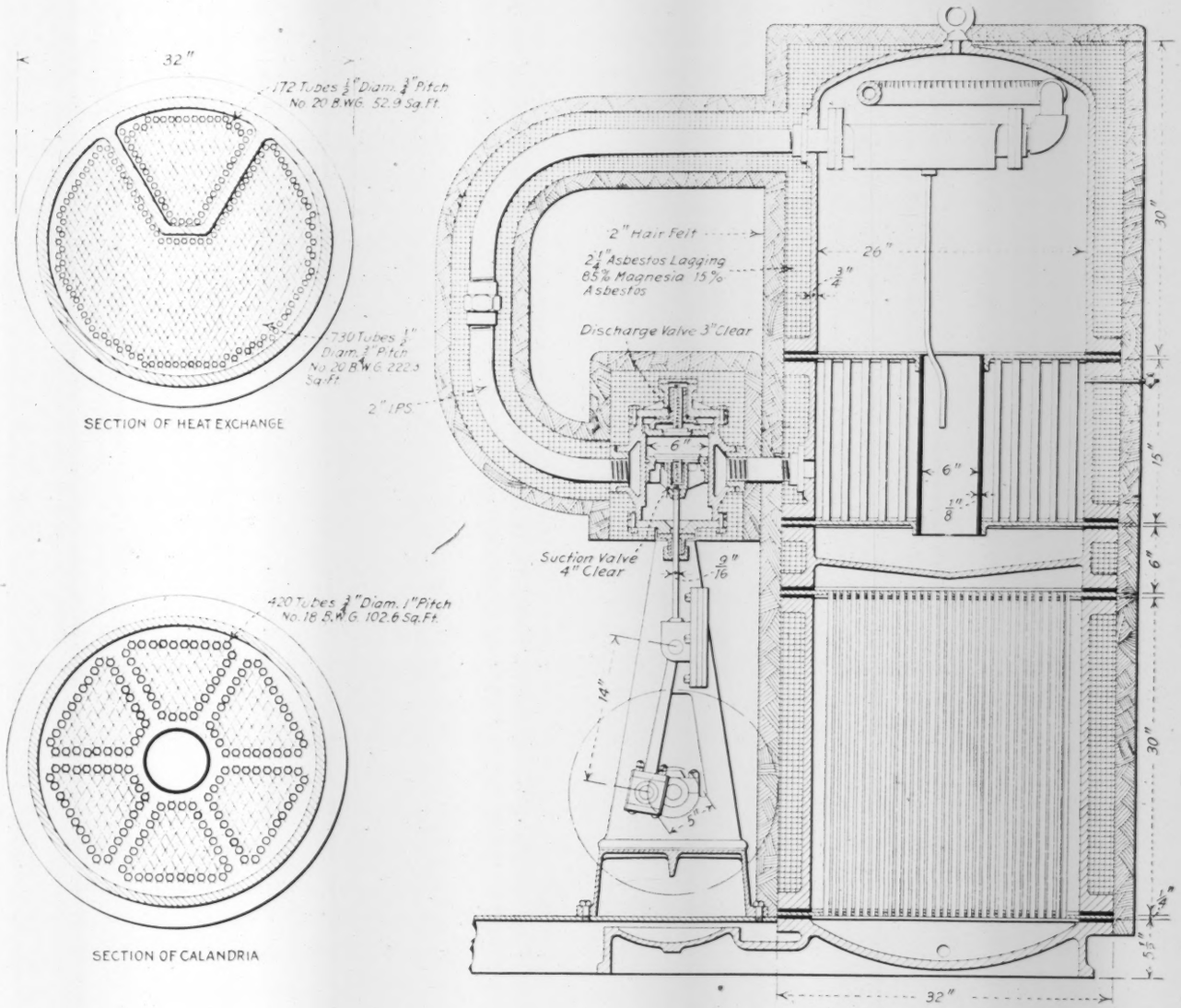

Fig. 10 Experimental Calandria designed for Testing out a Compression Cycle of Evaporation

[1] Mechanical Engineer, John H. Murphy Iron Works, New Orleans, La.

about 50 ft. per minute. Professor Kerr does not give the size nor speed of this pump, but having seen his apparatus personally, we are confident that the displacement was far in excess of that suggested above. This would naturally purge the calandrias more completely of the foul gases, producing very high rates of transmission.

(3) In all the experiments, the temperature of the feed to the evaporator was very low as compared with the boiling point in the apparatus during the tests. It also has been our experience, confirmed by many tests, that far better results are obtainable when the feed enters at or above the boiling point, especially if it is admitted below the tubes. Those of the Society who have had experience in the operation of apparatus of this kind in multiples have, doubtless, noticed that the temperature fall in the first of a triple or quadruple effect is always greater than in the second, in spite of the greater density of the liquor in the second body. This is, doubtless, due to the fact that in the first body, the feed is generally below the boiling point, and in the second considerably above it.

The surface in a multiple effect is designed for evaporating and not for heating. To prove this contention, we have tried to use a single body as a surface condenser with water on the inside of the tubes and steam on the outside, and we secured very poor results. As soon, however, as the liquid begins to boil, there is a remarkable change in the coefficient of transmission. This is due to the slow velocity of circulation when the surface is being used for heating, as compared with the very rapid circulation when it is used for boiling. We understand that it has been established in surface condenser practice that the coefficient of heat transmission is proportional to the square root of the velocity of the condensing water in the tubes. The same law should hold good with evaporator practice.

With slow evaporation, small bubbles of steam cling to the surface actually insulating it from contact with the boiling liquid, and it is only after the circulation is established that these are swept off, so that we can readily understand why higher rates of evaporation give higher coefficients, and long tubes are better than short ones.

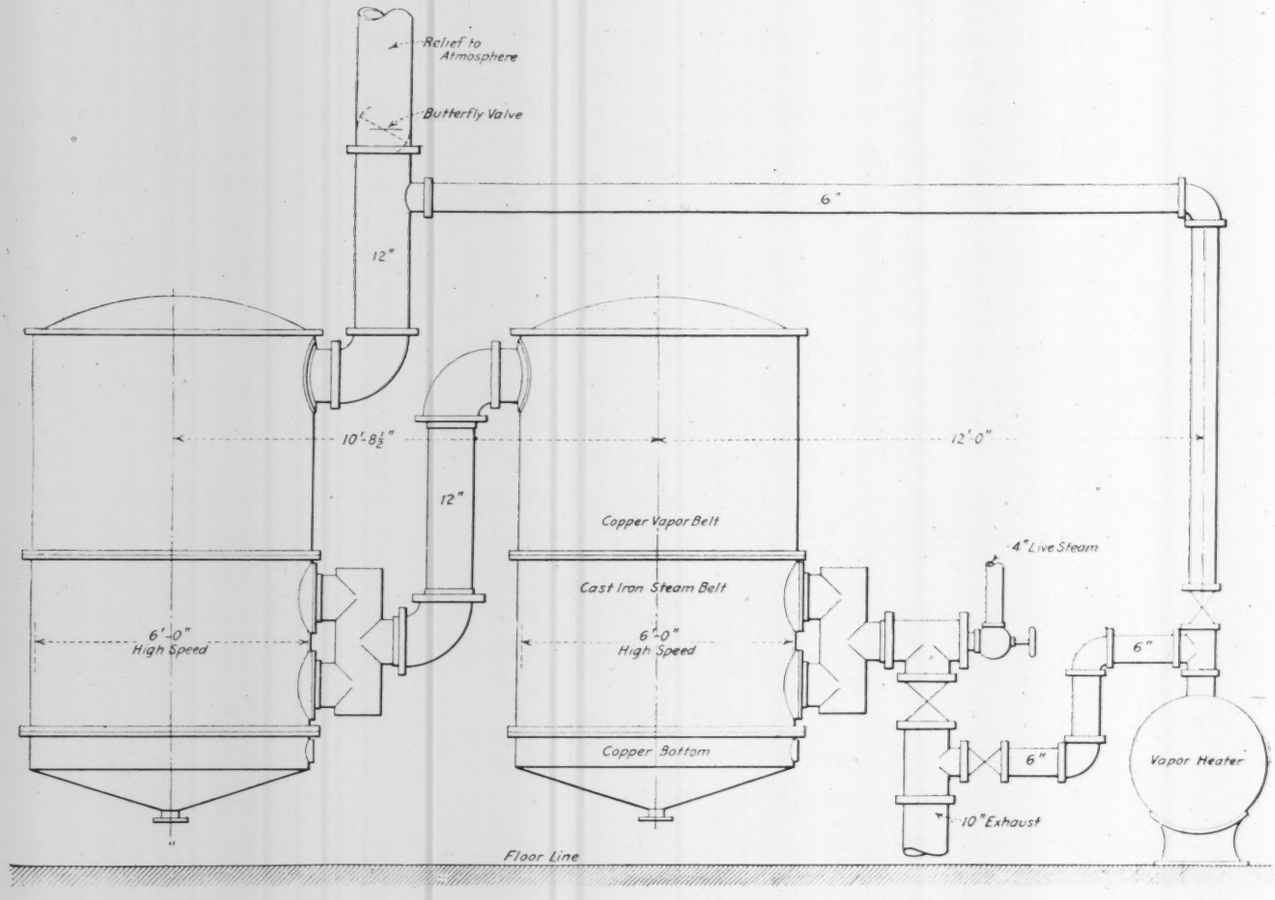

FIG. 11 DESIGN OF ATMOSPHERIC DOUBLE-EFFECT EVAPORATOR WITH VAPOR HEATER

In this connection, we believe that we should be very guarded about coming to conclusions as to the relative merits of calandrias equipped with and without downtakes. This feed temperature problem would naturally affect the calandria without downtake more than the one with a downtake, and might neutralize the apparent advantage shown in Professor Kerr's tests, for it is a fact that there are many effects in Cuba without downtakes giving excellent results, fully as good as those otherwise equipped.

(4) We do not quite agree with Professor Kerr on his comparison of the compromise curves shown in Fig. 9. These curves are made up by altering those shown in Fig. 8. It

will be noted that for both calandrias *D* and *E*, the two temperature level runs were not made with the levels at the points of maximum evaporation, as shown by the juice level series. These points were 18 in. for *D* and 5 in. for *E*. The points selected were 36 in. for *D* and 12 in. for *E*.

Professor Kerr's compromise curves were made by selecting 18 in. as the compromise boiling level. Inasmuch, as on the level series *D* showed a coefficient of 1,257 at 18 in. and 1,025 at 36 in., the curve was boosted up in the ratio of 1257 to 1025, bringing the said coefficient at exactly the maximum point for *D*. This is perfectly satisfactory as far as *D* is concerned. But when the same level is assumed for *E*, and the coefficients are lowered in the ratio of 1256 to 1120, a point nearly 24 per cent below its maximum, we consider that *E* is then at a disadvantage of 24 per cent as compared with *D*.

According to Prof. Kerr, himself, longer tubes give higher coefficients. It is logical to conclude, therefore, that if *E* had had 54-in. tubes as *D* had, it would have shown higher rates of transmission than it actually did show, and with a level of 18 in. would have shown its maximum which would have been above the maximum for 24-in. tubes. It seems to us, therefore, that in order to give *E* an even break levels of maximum evaporation should have been selected if any comparison was to be made at all.

In connection with the high rates of evaporation shown by *E*, which is of our design, we have secured considerably higher coefficients in actual practice. On one of our triples, evaporating 8 lb. per sq. ft. per hour, the drop of temperature in the first body was only 5 deg., and in the second 8 deg. Our ability to boil with a *small drop* has suggested that we operate our effects without vacuum. This we are now doing with remarkable success in atmospheric double-effect evaporators. The capacities are about the same as in the old double effects running under vacuum. Fig. 11 illustrates the arrangement of apparatus for the atmospheric double effect with vapor heater, which has the advantage of doing away with vacuum and water pumps, and the water supply necessary to operate the effects. The pressure in the first calandria is from 6 to 8 lb., which is entirely permissible. The vapors leaving the last body are used for juice heating, which, of course, leaves the largest part uncondensed. It is our intention to use these vapors to operate a vapor vacuum pan.

We want to extend to Professor Kerr our thanks for the painstaking work which he has done, and the valuable information he has worked up. His tests have established facts, which were known only approximately before, and are very useful in that they point the way to scientific design and operation. Experiments, such as he conducted, are impossible on large equipments, and by making proper allowances for this fact, we can interpret their true meaning, and we hope he will incorporate all his data in a good text book, which would be of great service to both manufacturers and operators.

THE AUTHOR. In reply to Mr. Fisher's criticism regarding the short duration of the tests, I will state that the pressure in the heating compartment, also the vacuum in the boiling compartment, was very carefully regulated in all the tests. In fact, they were maintained practically constant throughout each test. Considerable preliminary work was devoted to this matter and the length of the tests was decided upon after it had been shown experimentally that the results were uniform. This is corroborated by the smooth curves shown in the text of the paper. In view of the constant conditions maintained it is believed that the tests were not too short for reasonable accuracy.

The writer agrees in the main with Mr. Webre's observations regarding the fact that the coefficients of heat transmission in the small experimental evaporator used in the tests were greater than are obtained in full sized units; also his reasons therefor, though I will have to take issue with him in some instances. The condensate was removed by a direct-acting 4½ by 6 by 7 in. steam pump, the piston speed being about 40 ft. per min., except in the tests to determine the effect of air where it was varied through wide limits. The displacement of this pump was relatively greater than is generally used in full sized units and this would probably increase the heat transmission somewhat, not only because of a more complete removal of incondensable gases but because of increased steam circulation as well. However, as the speed was kept practically constant for the tests on all the different types of evaporators the results are sufficiently accurate for comparison.

I am inclined to believe that the relatively cool feed would increase rather than decrease the velocity of circulation. Moreover, most of the tests were made with greater rates of evaporation per square foot of heating surface per hour than are usually obtained in practice, which would mean that the velocities of circulation were also greater. In my opinion one of the principal reasons for the high coefficients of heat transmission in the experimental apparatus was the perfectly clean condition of the heating surface, which cannot be maintained in practice even under the most favorable conditions. There seems to be a progressively increasing fouling of evaporator tubes toward the end of the factory grinding season even when they are boiled out regularly with soda and acid.

Mr. Webre's statement that it is not practicable to obtain a coefficient of transmission greater than 250 in everyday work with large units is correct, though it should be remembered that the coefficient is greater in the first body of a multiple evaporator than in the last body and this figure would represent a good average. The writer has lately made some tests upon a large quadruple film evaporator where transmission coefficients for the four bodies were 545, 648, 600 and 207 respectively, the average being 394. The difference between these coefficients and most of those shown in the paper is not excessive.

I agree with Mr. Webre that the compromise curves of Fig. 9 show the relative heat transmission of the different types only approximately. The juice heads 18 in. for calandria D and 12 in. for E were used instead of those of maximum evaporation because it was thought they would be approximately the same as would be used in practice. With the 24-in. tubes of E, it is quite natural that lower heads can be carried than with the 54-in. tubes of D. It is evident that the calandria with tubes 24 in. long has an advantage over those with tubes 48 in. and 54 in. long as regards juice head; also the heads for maximum evaporation would be lower with the 24 in. tubes. I am inclined, therefore, to think that compromise curves corrected to maximum evaporation heads would not furnish a fair basis of comparison for these two types. Tests recently made on full sized evaporators of types D and E seem to indicate that the ratings shown by the compromise curves are not far from correct.

TESTS OF VACUUM CLEANING SYSTEMS

By J. R. McColl, Detroit, Mich.

Member of the Society

The paper gives an outline of some tests of vacuum cleaners made for the Board of Education, Detroit, Mich. The tests were divided into two series: (*a*) with the machines on hose and piping as presented or recommended by the manufacturers; and (*b*) with all machines on the same hose and piping system, for the purpose of direct comparison. Each of these series was divided into two parts: (1) tests for ability to do work at the tool end of the hose; (2) analyses of machines as machines.

The paper outlines some of the fundamental principles of vacuum cleaning and contains various curves and tabulated data giving the results of the tests in detail, covering energy developed, power consumption, losses in hose and piping, efficiency, etc.

The specifications provided that in grading machines the ability to do work should not count for more than two-thirds of the total score. It was the sense of the committee who assisted that a machine which makes a fine showing in ability to do work and yet has a low score as a machine is as much to be avoided as one which gains a high score as a machine and shows a poor ability to do work. The two features must be considered together in rating a machine. After going over various details involved, the consensus of opinion was that for a school building, 60 points should be

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TABLE 1 RESULTS OF TESTS

1	2	3	4	5	6	7	8	9		10	11	12			
Designating Letter	Type of Machine	No. of Sweeper	Size of Piping, In.	Size of Hose, In.	Score	Electric Current Consumption in Kw-Hr. For Column 9	Electric Current Consumption in Kw-Hr. For 80 cf. Fr. Air	Cu. Ft. Free Air for 1 In. Vacuum Inside Orifice		Vacuum at Machine for 80 Cu. Ft. Free Air per Minute per Hose	Apparent Displacement at Machine for 80 Cu. Ft. Free Air	Pull to Move Following Lengths of Hose on Floor in Lb. 75 Ft.	37½ Ft.	25 Ft.	12½ Ft.
		As proposed—one-sweeper capacity													
F_1	Rotary Exhauster.....	1	2	1½	93.4	2.72	3.23	86.6	2nd test	7.13	106.0	18.25	8.25	5.5	3.0
D_1	Multi-Stage Fan.....	1	3	1½	93.2	1.85	1.76	90.5		3.75	92.0	22.5	9.5	7.0	3.5
G_1	Single-Stage Fan.....	1	3	25′=2¼″+50′=1¾	85.6	1.62	.....	61.5		.....	.....	22.0	7.0	4.5	2.5
F_1	Rotary Exhauster.....	1	2	1¼	84.0	2.15	.....	67.3	1st test	.....	.....	13.0	5.5	4.75	2.5
C_1	Rotary Exhauster.....	1	2	1¼	82.0	2.5	2.5	82.0		76.2	108.5	19.5	9.0	4.75	2.5
		As proposed—two-sweeper capacity													
G_2	Single-Stage Fan.....	1	3	50′=2½″+25′=1¾	97.6	1.95	.95	177.8		2.07	86.0	22.0	7.0	4.5	2.5
F_2	Rotary Exhauster.....	2	2	1½	85.5	3.95	.....	142.0	2nd test	.....	.....	18.25	8.25	5.5	3.0
B_2	Rotary Exhauster.....	2	2	1¼	83.0	9.25	4.22	175.5	2nd test	9.87	121.0				
F_2	Rotary Exhauster.....	2	2	1¼	78.7	3.99	.....	115.3	1st test	.....	.....	13.0	5.5	4.75	2.5
B_2	Rotary Exhauster.....	2	2	1	66.0	10.8	.....	93.8	1st test	.....	.....	23.0	10.75	5.5	4.0
E_2	Reciprocating, Plunger.	2	2	1¼	57.7	11.5	5.37	169.0		9.55	118.8	19.5	9.0	4.75	2.5
A_2	Reciprocating, Plunger.	2	2	1	35.4	6.7	.....	97.1		.....	.....	25.0	13.5	8.5	5.25
		Comparison on school board hose—one sweeper													
F_1	Rotary Exhauster.....	1	3	1¼	90.3	3.11	3.1	80.8		7.3	107.0				
F_1	Rotary Exhauster.....	1	2	1¼	88.9	3.27	3.0	78.2		.....	.....				
D_1	Multi-Stage Fan.....	1	3	1¼	86.9	1.65	.....	59.0		.....	.....				
C_1	Rotary Exhauster.....	1	3	1¼	80.5	2.45	2.5	78.8		7.25	106.5				
G_1	Single-Stage Fan.....	1	3	1¼	68.7	0.7	.....	28.0		.....	.....				
		Comparison on school board hose—two sweepers													
F_2	Rotary Exhauster.....	2	3	1¼	83.9	4.67	.....	135.0		.....	.....				
B_2	Rotary Exhauster.....	2	2	1¼	83.0	9.25	4.22	175.5		9.87	121.0				
F_2	Rotary Exhauster.....	2	2	1¼	82.0	4.25	.....	128.4		.....	.....				
B_2	Rotary Exhauster.....	2	3	1¼	75.3	3.5	.....	131.0		.....	.....				
G_2	Single-Stage Fan.....	2	3	1¼	72.3	1.45	.....	69.5		.....	.....				
E_2	Reciprocating, Plunger.	2	3	1¼	61.5	12.73	6.5	183.0		10.1	122.5				
E_2	Reciprocating, Plunger.	2	2	1¼	57.7	11.45	5.37	168.6		9.55	118.8				
A_2	Reciprocating, Plunger.	2	3	1¼	48.5	5.4	.....	148.7		.....	.....				
A_2	Reciprocating, Plunger.	2	2	1¼	45.8	5.3	.....	139.0		.....	.....				
		3-in. Piping and proposed hose													
F_1	Rotary Exhauster.....	1	3	1½	95.3	2.58	3.15	90.8		7.1	105.6				
F_2	Rotary Exhauster.....	2	3	1½	86.3	3.82	.....	146.0		.....	.....				
G_1	Single-Stage Fan.....	1	3	25′=2¼″+50′=1¾	85.6	0.78	.....	61.5		.....	.....				
C_1	Rotary Exhauster.....	1	3	1¼	80.5	2.45	2.5	78.8		7.25	106.5				
A_2	Reciprocating, Plunger.	2	3	1	34.4	6.9	.....	94.0		.....	.....				

given to the machine as a machine and 40 points to its ability to do work. This was of course an arbitrary standard, regarding which there would no doubt be a wide diversity of opinion among engineers, but as long as all machines were scored uniformly in accordance with this assumed standard, it has the stamp of fairness. The 60 points for the machine as a machine, were divided as follows:

Maintenance and repairs	20	
Simplicity	5	
Lubrication	5	
Dust collection	5	
Space	5	
Noise	5	
Tools and hose	15	60
Ability to do work		40
		100

The specifications provided that the vacuum cleaning system must be of a capacity to take care of two sweepers operating simultaneously on a given system of piping, each sweeper to be provided with 75 ft. of hose. The capacity requirement for each sweeper was stipulated as 80 cu. ft. of free air to be handled with a vacuum of 1 in. of mercury inside an orifice at the tool or sweeper end of the hose.

DISCUSSION

H. M. Grossman[1] (written). The extreme value of Mr. McColl's paper lies in the fine comparison which the data give of the three different types of vacuum cleaning machines: namely, the reciprocating plunger or piston pump type; the rotary exhauster type; and the high-speed centrifugal fan type of either single or multistage design. The development of the vacuum cleaning industry has been very rapid during the past three or four years, and as the industry grew this development has brought out the three distinct types in the following order:

The Reciprocating Plunger or Piston Pump Type. This machine consisted of an ordinary cylinder with a reciprocating piston working therein, and with the usual intake and exhaust valves. This plunger or piston pump design was admirably adapted to the production of a high vacuum, but the ability to displace air when the various cleaning tools were in operation was very limited. The fact that the piston pump had always been used when it was necessary to produce a vacuum led naturally to the use of the same device in producing the vacuum for the first vacuum cleaners. In the design and construction of the first type of vacuum cleaners the inventors and builders did not recognize the fact that the volume of air in motion was the essential cleaning agent and that the vacuum was only a means for causing this flow of air.

Since the characteristics of this machine were inherently high vacuum with a very low air displacement (or high-vacuum low-volume) it was equipped with a piping and hose system of very small diameter. The cleaning tools were also made of very small size. The result of this small pipe, hose and tool equipment was constant trouble from clogging of the pipe system, together with a general inability of the cleaning tool to pick up anything except the finest dust. These facts, coupled with rapid wear and tear in the elaborate mechanism of the machine itself, led to almost endless trouble, and required the services of a skilled mechanic to keep it in operating condition. The machine also required an elaborate system of separating tanks to separate every particle of dust from the air before drawing it into the cylinder. Even with the greatest of precaution it was frequently necessary to rebore the cylinder after less than a year of use. Naturally, the cost of maintenance of this type of machine was very high. The power required to drive was also very high as compared with the later types.

The Rotary Pump or Rotary Impeller. This type of machine was brought out with the idea of obtaining greater air displacement per sweeper with less vacuum maintained at the machine; also, with the hope of eliminating the trouble experienced in the first type due to excessive wear of the piston and cylinder. The second type of machine did eliminate all reciprocating parts and substituted a true rotary motion in the vacuum producer, which, in itself, was a decided advantage. The vacuum producer consisted of a casing with a series of close fitting blades or impellers revolving therein. In order to maintain the necessary vacuum the clearance between impeller and casing had to be made exceedingly small, which again caused trouble as soon as a small amount of dust or dirt reached the impeller; therefore, this machine required the same elaborate system of dry and wet separating tanks to protect the vacuum producer from excessive wear. This system used pipe, hose and cleaning tools of almost the same size as the first type mentioned, but the power required to drive this machine was much less.

The High-Speed Centrifugal Fan Type. The third and final step in the development of the vacuum cleaner is found in the adoption of the high-speed centrifugal fan, which brings us to the present style of machine, so successful commercially. This type of machine is designed on a new principle entirely, namely, high-volume and low-vacuum. In other words, the vacuum cleaning industry has developed until it recognizes that a large volume of air in motion is required to do rapid and effective cleaning; or, that a comparatively large volume of air in motion is the only cleaning agent, and that the vacuum is nothing more than a means to cause this air to flow.

The machine consists of a high-speed centrifugal fan revolving freely in a snail casing and direct connected to a motor or steam turbine. The volumetric capacity of the fan for displacing air is very large as compared with the first and second types of machines, while the vacuum maintained at the machine is comparatively low. Due to the inherent qualities of a centrifugal fan to displace air, the vacuum maintained at the machine is practically constant regardless of the number of sweepers in operation. The piping system, vacuum hose and cleaning tools are all considerably larger than in the previous types, thus permitting a large volume of air to pass, which, in turn, means a high velocity around the tool lip and a consequent thoroughly effective cleaning of the fabric or floor over which the tool is passed. The separation of the dust and dirt is accomplished by the gravity process, which eliminates all trouble breeding cloth bags and water sprays such as were necessary in the first and second types.

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The design and construction of the machine itself is so simple and rugged that the only attention required is an occasional oiling of the bearings and the emptying at intervals of the dirt receptacle. Self-aligning ball bearings running in a constant oil bath constitute the only frictional or rubbing parts. This type of machine has decided advantages, such as simplicity of design, low first cost, low cost of maintenance, low power consumption, great durability, and ability to do fast and thorough cleaning.

There is another very important point in connection with all vacuum cleaner installations of the past which has been overlooked or neglected in most cases. This point may be summed up in just four words: Too Much Vacuum Hose. In other words, the practice has been in the past to use a piping system of so few risers and of such limited extent that it was necessary to use from 75 to 100 ft. of hose per sweeper in order to reach all parts of the building. The vacuum hose is the particular part of an installation that receives the greatest wear and tear; at the same time it is the weakest, and the most expensive part of the installation. Therefore, in order to reduce the amount of vacuum hose necessary, the piping system should be more extensive; that is, provided with a greater number of risers and inlets throughout the building than has been the custom in specifications of the past. The engineer, architect, and building manager, when in position to do so, should always specify a piping system that will require the use of no more than 50 ft. of vacuum hose per sweeper. This sort of piping installation will reduce the cost of maintenance to a minimum and also make the cleaning of a building a far easier task. In fact, this item alone will reduce the cost of janitor service (including time and repairs) several cents per rentable foot. Therefore, let us always insist on "more risers and inlets, with shorter lengths of vacuum hose."

Charles R. Thurman (written). Mr. McColl has evidently given the matter much thought and has brought out some interesting points in connection with a subject which is rather vague in the minds of many writers of specifications. One point upon which there is a wide difference of opinion among manufacturers and engineers is the quantity of air required to do good cleaning. The author has selected 80 cu. ft. per min. with 1 in. of mercury suction at the end of the hose. This is a good figure for heavy duty, but it is unnecessarily high for ordinary work. A good normal quantity for work of the grade found in school houses would be between 60 and 70 cu. ft. per min. and for residence work, 50 cu. ft. per min. is ample. In all cases there should be a surplus vacuum of approximately 1 in. of mercury above what is required to overcome friction losses.

The author refers to the lack of uniformity among manufacturers in regard to the size of the tools and hose used: The wide variations are indeed astonishing to one who understands the important part played in a vacuum cleaner installation by the hose losses. The writer knows one manufacturer who sometimes uses ¾-in. hose and tools on one of his stationary machines, and another manufacturer who uses 1¾-in. hose and tools. The friction losses in the former are nearly 70 times as great as in the latter, for the same flow of air.

It is the policy of the writer to employ the largest hose that will be acceptable to the average user, provided it can be made with sufficient strength to stand the wear and flexibility enough not to be unwieldy. The result of this policy has been the adoption of two standard sizes: 1½ in. for office buildings, school houses, etc., where the work is done by male janitors; and 1¼ in. for household work, which is usually done by maids.

Mr. McColl has brought out a very important point in regard to the limiting size of horizontal mains. This is a point which seems to have escaped a great many designers of stationary installations. It is interesting to note that the writer, entirely independent of Mr. McColl, arrived at a value for the minimum permissible velocity in horizontal pipes to prevent settling of the heavier particles of dirt, which was just 10 per cent lower than the figures given in the paper. This is all the more remarkable when the difficulty of determining such a quantity, even approximately, is considered.

Too much care cannot be taken in making specifications for apparatus to be used in the field for determining the performance of machines. For this purpose, the apparatus must be simple, cheap and easily reproduced. The object of such field tests is to ascertain whether the installation meets certain specifications as regards, what Mr. McColl has styled, "ability to do work." The criterion for such test is usually the suction available at the end of the hose, when the desired quantity of air is flowing. The simplest apparatus for this purpose is a tube to be inserted in the end of the hose and equipped at its outer end with a variety of simple thin plate orifices. A pressure hole is provided in the side of this tube at a distance back from the orifice not less than twelve times the diameter of the tube. In practice, the tube is inserted in the end of the hose and the vacuum measured at the pressure hole with each of one or more sizes of orifice called for in the specifications. This method of test presents an easy means of checking up the "ability to do work" and is one that may be easily standardized and calibrated so that the flow of air may be computed from the size of the orifice and the vacuum measured.

If the pressure hole is too close to the orifice, the result will be misleading. The writer has often observed a vacuum just back of the orifice considerably greater than that at the exhauster, even when there was a long piece of hose between. This phenomenon is due to the velocity conversion in the tube after the pressure hole is passed.

The zones suggested by the author for the different grades of work do not indicate mature thought. In all vacuum cleaner work, due consideration must be given to the workman doing the cleaning, and experience shows that vacua of more than 3 in. of mercury maintained in the tool imposes a heavy burden of labor upon the operator, owing to the adhesion of the tool to the surface. In bare floor tools this difficulty is overcome by various schemes for letting in a rush of air, but for carpet cleaning, such a device defeats the end of the vacuum cleaner by admitting a lot of air, which does not pass through the carpet, and serves only to diminish the vacuum and hence the flow through this fabric. A satisfactory cleaner must have ample air displacement to take care of the fluctuations in demand, due to the rapidly changing action of the tool, and for bare floor work, and must be limited in suction to such a value that the operator is not overworked. In the centrifugal fan type of machine this result is obtained automatically, while in the positive displacement type, recourse must be had to by-passes or pop valves.

The curves showing the relation between the wasted energy and available energy at the tool are very clear. The

large percentage of energy absorbed by the piping system and long lengths of hose required by stationary machines make very evident some of the advantages possessed by the portable and so-called truck machines now on the market, in the use of which the piping losses are entirely eliminated and hose losses reduced from 50 per cent to 75 per cent by reducing the length required.

THE AUTHOR. I fear that Mr. Grossman in his evident enthusiasm for one type of machine has overlooked many good features of the other types, types which are far from obsolete at the present writing. It was the prophecy of one of the committee who assisted us, that the relative standings of the reciprocating, rotary pump, and fan types of vacuum cleaners will ultimately be similar to those of the steam prime movers of the reciprocating, rotary and turbine types. This doubtless will be a long way off, for vacuum cleaners will never have the prominence in engineering and commercial fields that steam engines have had.

The mechanical efficiency of the fan type of vacuum cleaner, working, as it must do, on a fairly low ratio of opening, is much lower, as a machine, than some of the other types, but its greater simplicity is a valuable offset. The low power consumption shown by some of these machines, for a given duty, is a result of large hose and piping rather than high mechanical efficiency of the machine.

The small hose and piping systems used in the earlier vacuum cleaner work, and still used by some manufacturers, required high vacua at the machines, a matter more of necessity than choice, to get practical results in cleaning. There is no reason why these same machines cannot be used, or at least be designed to be used, on a large hose and piping system as "low vacuum—high volume" machines with surprising results in air handled and diminished power consumption. Machine B_2 (Table 1) for example had a displacement nearly double that which it would have needed on the hose and piping system of G_2. The use of the larger hose and piping systems with the fan type of cleaners, particularly the single stage type, is also more a matter of necessity than choice, and some excellent engineering has been done in adapting these machines (capable of only about 2 in. vacuum as a maximum for a practical unit) to rapid sweeping work.

Piping systems are now quite often installed by heating contractors for adaptability to various kinds of vacuum cleaners, with a view that the machine can be purchased and installed later. If the time ever comes when the hose and tools can be purchased from a general supply house by intelligent selection of engineers and clients, according to the maximum size the user will stand for independent of any particular vacuum cleaning machine, then we shall arrive at an era when the true comparative merits of vacuum cleaning machines, as machines, will be found out as fully as electric motors are now known, independent of the feed lines, or as steam engines independent of steam and exhaust lines.

My experience with thin plate orifices, outlined by Mr. Thurman, has not been entirely satisfactory, probably due to varying *vena contracta* effects. It seems to be desirable to get away as much as possible from eddies near the orifice even though the pressure tube connection is through a capillary hole smoothly finished with the inside of the orifice holder. The exact design of orifice and holder must be given if vacuum-orifice or volume-orifice requirements are specified.

A NEW PROCESS OF CLEANING PRODUCER GAS

By H. F. Smith, Lexington, Ohio

Member of the Society

The tar and other mechanical impurities present in raw bituminous producer gas are in an extreme state of subdivision. The number of particles present is so great and the quantity of gas to be handled in commercial plants so large that the problem presents more than ordinary difficulties. The effectiveness of the ordinary types of mechanical gas washers and purifiers leaves much to be desired. The primary object has accordingly been to produce equipment that will be capable of yielding gas of a higher degree of cleanness than obtainable by ordinary methods.

The gas to be cleaned is first cooled sufficiently to condense the tar vapors and the gas and tar are then passed under pressure through a porous diagram of spun glass. This is in the form of ordinary glass wool (which should be distinguished from slag wool), placed between two metal screens. In passing the diaphragm an important change occurs in the physical state of the tar. On the entering side, the tar exists in a large number of minute particles ordinarily known as tar fog. In passing the diaphragm these particles coalesce, so that on the discharge side the tar particles are of relatively large dimensions which cannot be carried along with the gas current and immediately separate out by gravity.

Any desired degree of gas cleanness can be secured, and no water or other washing fluid is required. That the process is not one of filtration is shown by the fact that in filtering the best results are secured when the rate of flow through the filtering medium is slow, whereas in the present process good results can be secured only when the velocity through the diaphragm is very high; and further, there is no deposit in the diaphragm as in filtration.

The apparatus in its present stage of development is shown in Fig. 2. The raw producer gas on leaving the producer is first cooled to a point where the tar vapors are condensed by being passed through a primary cooler or condenser. From this the gas is carried into an ordinary rotary gas pump B which delivers the gas under pressure into the main C; it is then delivered through the diaphragm E and discharged from there into the main F. A sump or separator G is provided in which the tar accumulates.

It appears to be possible to secure almost any desired degree of gas cleanness simply by regulating the pressure maintained across the diaphragm. A difference in pressure of from 2½ to 4 lb. will give a degree of gas cleanness that is ample for any commercial

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requirement. Thirty cubic feet of gas cleaned in this way can be passed through a white filter paper without producing any discoloration.

The exact method by which this tar extractor operates has not been conclusively demonstrated. One theory is that the tar particles are precipitated by being brought into direct collision with the threads or filaments of the porous diaphragm. That this does not constitute a complete explanation of the process, however, is indicated by the fact that the material of which the porous diaphragm is constructed has a marked bearing on the effectiveness of the process, steel wool, for example, being much less effective than the spun glass.

The author believes, as a result of experiment, that friction is in some way concerned in the process. He

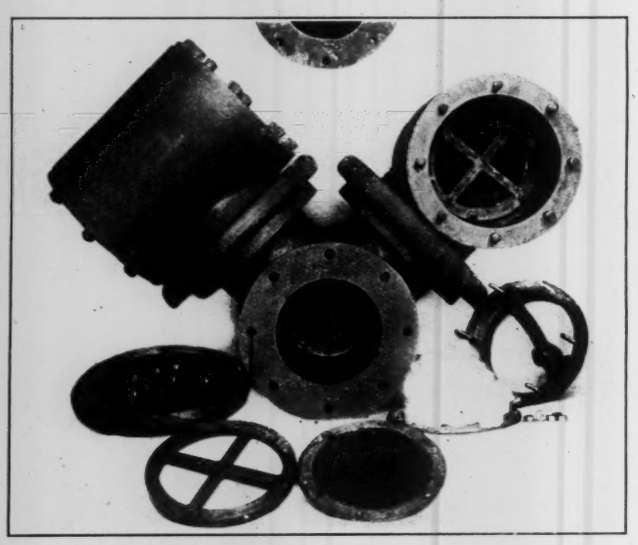

Fig. 1 View showing Various Parts of Commercial Extractor

found that if the gas is caused to pass through a small glass tube with perfectly smooth walls, no particular precipitation of tar occurs as long as the velocities of travel are slow; but that as the velocities increase to a point where there is considerable friction between the gas and the surface of the containing tube, a heavy precipitation of tar occurs on the surface of the glass.

Since friction between rapidly moving gases and containing tubes is known to be productive of electrical phenomena, it was assumed that this might have some bearing on the action. Experiments were conducted with electrodes by which precipitation of the tar particles was effected, and the results were such as to indicate that if the distance between the electrodes could be reduced sufficiently, the differences in potential required for effective electrical action would be very small. He concludes, therefore, that in addition to the effects of mechanical collision there may be a distinct electrical attraction exerted by the glass fibers constituting the porous diaphragm which are located at microscopic distances from each other and which are undoubtedly subjected to some electrification from friction with the gas currents. If the possibility of such electrical action is considered, the increased effectiveness of glass as compared with steel for the construction of the porous diaphragm is satisfactorily explained. That friction of this nature is capable of producing electrical disturbances of considerable magnitude is well established.

DISCUSSION

F. R. Hutton (the chairman) said that the author had brought out an important fact, in establishing that on the discharge side the particles are very much larger and the product is very much less of an emulsion than it is on the upstream side of the porous diaphragm.

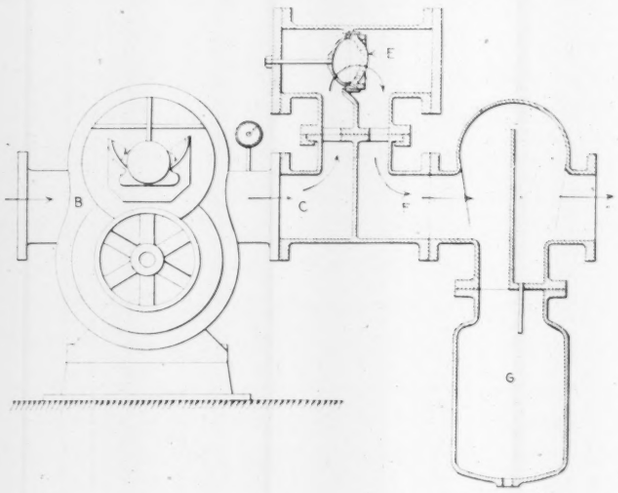

Fig. 2 Details of Static Scrubber and Connections to Blower and Separator

The suggestion of electrical action might also be supplemented by the reference in another paragraph to the fact that at certain velocities there is considerable friction between the gas and the surfaces over which it passes, which causes a heavy precipitation of tar on the surface of the glass. If he had added cohesion of the particles he thought the idea might have been expressed more fully.

Another striking feature of the author's presentation is the significance of spun-glass as compared with any other medium. This means that it is not a filtration, as the particles are not left on the filtering or separating diaphragm. It provides for a cleansing of the diaphragm.

Prof. Wm. T. Magruder suggested as a third alternative the reason for the action of the spun glass is that of a colloidal action, which he did not believe the author had considered. He referred to the wonderful transformations that take place in organic chemistry by colloidal action.

R. H. Fernald. In regard to the power required (in reply to a question by Mr. H. J. K. Freyn) I have no authentic

figures, but the operators at the plants where this particular type of extractor is installed claim that the power required is much less than in the old type centrifugal tar extractor, one operator putting the amount at about 25 or 30 per cent of that required for the old type.

Regarding the claims of cleanliness advanced by Mr. Smith, I cannot make any specific comment other than to say that for some reason the operators find it desirable to change this spun glass at intervals of perhaps three to six weeks. This change is, however, a very simple one and can be made at any time in a few moments and the expense involved is a mere trifle. The frequency of these changes of the spun glass seems to vary with the operator and the interval between changes speedily increases as the operator becomes more familiar with this type of extractor. In one or two of the installations which I recently visited, the operators changed the spun glass at intervals of one or two weeks when the plant was first started. The time was soon extended to three weeks and later to six weeks. Whether the interval will ever be extended to a year is a point that I can not at present answer. In one or two of the plants using this type of extractor, the tar is found to be sufficiently free from water and of such quality as to be of commercial value. In one installation the engineer is credited with $1.20 per bbl. for the tar which he uses in other processes in the plant. It seems to be a tar of real commercial value.

Inquiry of the operators at the plants indicated that the material is comparatively inexpensive, and that comparatively little of the material has to be used, approximately one pound. It was a comparatively inexpensive item, but I do not know where the material is secured.

Some idea of the proportions of this tar extractor may be had if I state that the extractor shown by the author has an overall height of about 5 ft. from the base of the gas main to the top of the upper tee, that is, they are about 30-in. tees. As this plant was operated when I visited it, three of the tees were in series and the fourth was cut out. The tee that was turned at right angles to the main was entirely out of service, and it was then a simple matter to take off the cap and get at the grid containing the spun glass inside. The process of changing the material and cleansing the tar extractor is seen to be very simple.

It may be of additional interest to know that in one installation recently visited which has been operated for several years, considerable difficulty has been experienced from tar in the engines while using the centrifugal tar extractor, according to the statement of the operator. This same operator states that since changing to the new type of extractor outlined in the paper, some two months ago, they have had no trouble from tar in the engine, and they have had a great deal of satisfaction from this extractor.

This question of tar and other impurities from producer-gas in the cylinder of the engine is a very important one. I recently visited a producer-gas installation of 4000 h.p. The same company has another plant which I understand is of the same size, operating on natural gas. The statement of the company is to the effect that the monthly cylinder oil bill is very much more with the producer-gas engine than with the natural gas engine. This brings to our attention some important factors concerning the impurities in producer-gas and the necessity of careful cleansing.

The Author desired to present no closure.—EDITOR.

PRESENT STATUS OF THE LARGE GAS ENGINE IN EUROPE

By Prof. P. Langer, Aachen, Germany

Member of the Society

The tendency to utilize in gas engines the enormous quantities of waste gases from blast furnaces had its inception in Germany about 20 years ago. Large units were created by increasing in size the parts of smaller motors and by using a larger number of cylinders. The two-cycle system also seemed to offer a suitable method of operation for large engines, on account of its more efficient utilization of the mechanism as compared with the single-acting four-cycle system. Full success was not attained, however, until about 11 years ago when the large gas engine was brought to a high state of perfection by the Maschinenfabrik Nuernberg in the form of the double-acting four-cycle type, with two cylinders arranged in tandem.

It was recognized that the principles on which to base the design of large gas engines should involve (*a*) the greatest possible accessibility of all parts exposed to the gases of combustion, and (*b*) relieving the cylinder wall of the weight of the piston. These principles have not only been proved to be correct but their observance has been found to be a necessary condition for the success of large gas engines.

The gas engine puts much higher demands upon the attendant than any other prime mover. It creates its own potential energy by conversion of the chemically latent heat energy of the gas. Almost any defect of the machine, inherent or acquired, which interferes with the conversion of energy, acts destructively upon the machine, not to mention its influence upon the power output. The simple consideration that gas is being burnt without rendering its equivalent in power, leads to the conclusion that the balance is being transmitted to the cooling water under pressures and temperatures beyond what are permissible, and that exhaust gases unallowably hot are flowing around the exhaust valves. In the case of the steam engine a leaky piston does no further damage than to increase the steam consumption. The governor automatically adjusts for a longer cut-off and the engine pulls through as long as the boiler furnishes sufficient steam. With the gas engine, a leaky piston causes ignition at the wrong time which means a release of heat energy at a time and place when this energy can do no useful work. A continuation of the operation under such conditions is not permissible. Any attempt to force the operation would cause heavy damage to the machine.

It is the duty of the designer to face these facts and to design the machine in such a manner that it is pos-

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sible to give it the careful attention needed to prevent such disturbances. Such attention cannot be given when access to such vital parts as pistons, stuffing box packings and valves cannot be had without a long and difficult job of disassembling. The author knows of an engine which, after six years of continuous day and night operation, showed only 0.015 in. wear in the diameter of the cylinder. This success, although immediately traceable to the careful attention this machine received, is nevertheless indirectly due to the designer who made it possible to give such attention through the excellence of his design.

An instance of defective design in this respect is the case of a stuffing box in which it is possible to replace

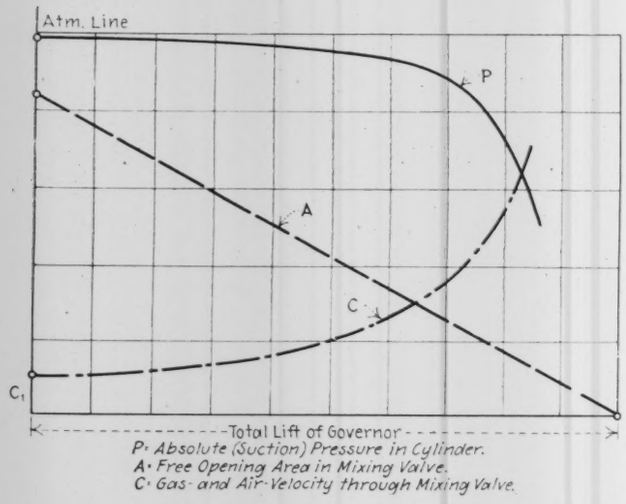

Fig. 1 Curve showing Relations of Opening of Mixing Valve, under Control of Governor, to Suction in Cylinder and Velocity through Valve

the packing rings only by unscrewing the joint between the piston rod and crosshead. The packing rings must needs be split and the whole packing must be easily removable in order that a new packing may be put in during a brief interruption of the operation. The result of neglecting this seemingly minor point of design is a continuation of operation with leaky packings and danger of warping the piston rods.

A further basic condition for uninterrupted operation is pure materials, pure gas and pure cooling water. Degrees of purity of 0.01 grains of dust in 1 cu. m. of gas and of 0.01 grains of dust in 1 liter of water must be attained by cleaning apparatus.

Operation with impure materials puts demands upon the operator which are impossible to meet, except by considerable reduction of the output on account of the long interruptions required for cleaning. It is evident that the economy of the plant suffers materially through reduction of the output, as the proportion of the unproductive capital, the idle machinery, increases. In comparison, the cost of good purifying apparatus for gas and water is of no consequence.

Regulation of Large Gas Engines

The attempt to attain stratification of the mixture inside of the cylinder has led to very complicated valve gears. It was hoped that a gas valve, which remained open during only a part of the suction stroke would direct the gas in such a manner that a combustible mixture would be present at the point of ignition even under the lightest loads, while the balance of the combustion space would be filled with inert air. The result, however, did not justify this hope. Instead of stratification there was only a bad mixture resulting in irregular and uneven operation. Today the hope of attaining stratification can be considered as being finally disposed of and designers have returned to the simple throttling valve gear.

Throttling of gas and air simultaneously, or in other words, regulation of the quantity of mixture only, is to be preferred to the throttling of gas only, as the former method is less sensitive and makes possible a more certain control of the power developed by the governor.

But even the simplest method of quantity regulation

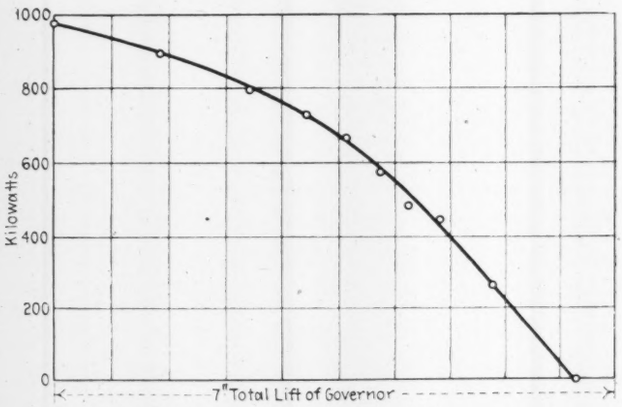

Fig. 2 Curve showing Effect of Proper Adjustment of Governor Mechanism to Obtain Uniform Utilization of Total Lift of Valve

will give satisfaction only if the action of the governor upon the throttle valve has been given careful consideration. Present and older designs that are faulty in this respect are frequently seen. It is wrong to let the governor act in such a way that the valve opening is proportional to the travel of the governor sleeve, as the following consideration will show:

The result of throttling is to reduce the quantity of mixture drawn into the cylinder during each stroke, on account of the reduced openings for gas and air. The volume of the charge remains the same, as the cylinder is always completely filled. The density of the charge will become less and correspondingly its weight and the amount of energy supplied.

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The result of this wrong regulation is marked irregularity of the indicator diagrams, as the smallest motion of the governor causes considerable changes in the quantity of mixture supplied. Combustion is irregular, there is tendency to backfire, or in a word, the machine "does not govern."

The remedy is found in changing the connection between the governor sleeve and the throttling mechanism in a manner such that in the low positions of the governor the throttling action is more intensive than in the upper positions. This action can be accomplished in a simple manner by offsetting the connecting link between the governor and the throttling valve, similar to the arrangement found in Corliss valve gears. This allows a uniform utilization of the total lift of the governor, and consequently stable and quiet regulation, without any complication whatever. Fig. 2 shows a diagram, characterizing the regulation as taken from an engine having a properly designed throttling gear.

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For a long time great difficulties were presented by the problem of driving variable speed blowing engines by four-cycle gas engines. In most cases the gas arrives at the mixing valve under a pressure of several inches of water above the atmosphere, while the pressure of the air is somewhat less than atmospheric. When the machine is run slower the suction action of the piston is reduced and the intake velocity of the air decreases more rapidly than that of the gas, until finally it is reduced to such an extent that nothing but gas enters the cylinder. It is self-evident that, even before this point is reached, the engine will choke with gas and will stop. A governor which regulates the quality of the mixture would only favor this suffocation of the engine with gas. In such cases, too, the conditions are improved by intensive throttling at normal speed.

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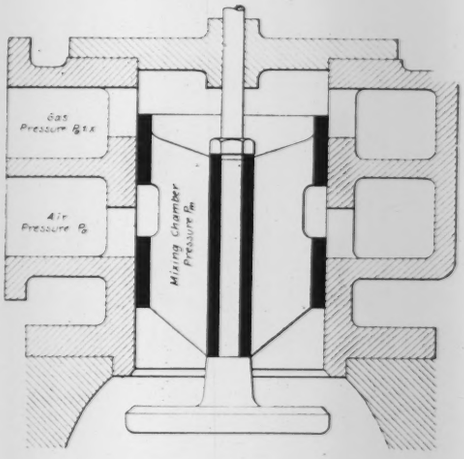

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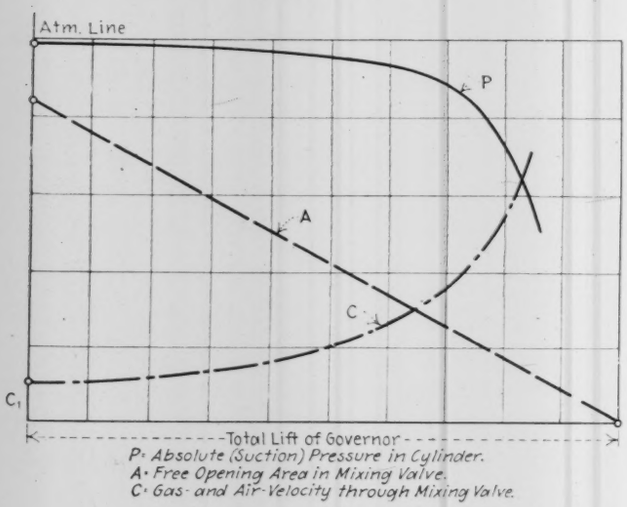

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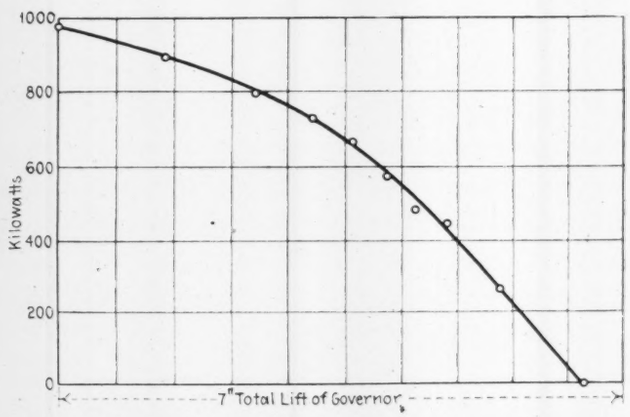

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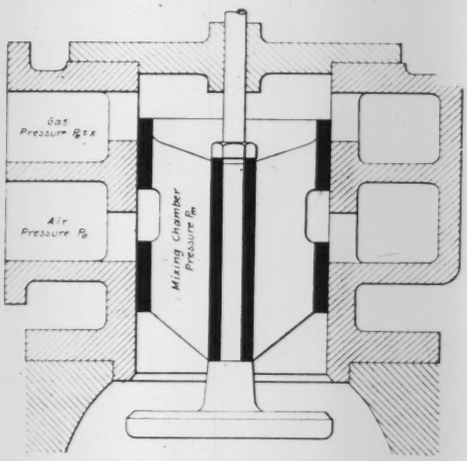

Fig. 3 Typical Design of Mixing Valve for Large Gas Engines

one-piece cylinders presents some difficulties, though these are not to be considered insurmountable.

Besides the advantage of simplicity and the absence of the danger of leakage in the highly strained cylinder joint, the one-piece cylinder allows a better transmission of the forces from the cylinder to the frame. The fact that one-piece cylinders frequently broke at the place indicated in Fig. 5, caused an over-estimation of the stresses in the casting. Closer investigation shows that the breaks are caused simply by making the part between cylinder and flange too weak. The wall, besides being too weak originally, is further weakened by the large number of cover studs and the break is further induced by excessive tightening of these studs. This fault can be remedied by properly reinforcing the point of danger and by placing the joint shoulder on the outside. As a matter of fact, breakage on account of strains in the casting or from expansion due to heat, has not occurred in cylinders that were properly reinforced. Improvements in foundry practice have undoubtedly helped to avoid such breakage.

While the breaks just discussed have their origin in the strains set up by irregular cooling of the casting or by irregular heating in operation, cracks of an entirely different nature have been observed on the walls of the combustion chamber. These so-called fire cracks always start in a place where the transmission of heat to the cooling water was impeded from some cause or other (see Fig. 6). The cause of these cracks is to be found in the stresses produced by unequal temperatures within the same wall. In the smooth and homogenous wall the differences in temperature of the different strata are small and the temperature of the wall is comparatively low, as long as accumulated scale or similar causes do not offer an obstacle to the transmission of heat. When, however, the capacity of the wall for conducting heat, or the rate of transmitting heat to the cooling water is reduced, there will be accumulation of heat which will cause a considerable rise of temperature during the expansion and exhaust strokes. The material will tend to expand according to the average temperature of the wall and it will be able to do this without resistance because it was under tension on account of the strain in the casting. In operation, therefore, the strain will be relieved. On account of temperature differences, however, in different strata of the wall, there will be stresses in the wall itself, compression in the hotter zones and tension in the cooler ones.

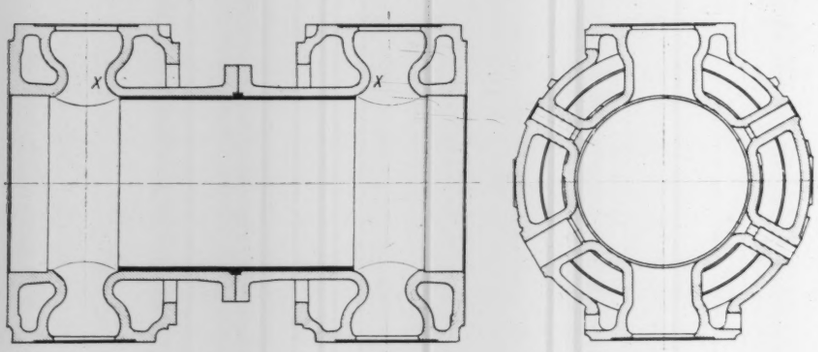

Fig. 4 Design of Split-Jacket Gas Engine Cylinder with Split Inside Cylinder

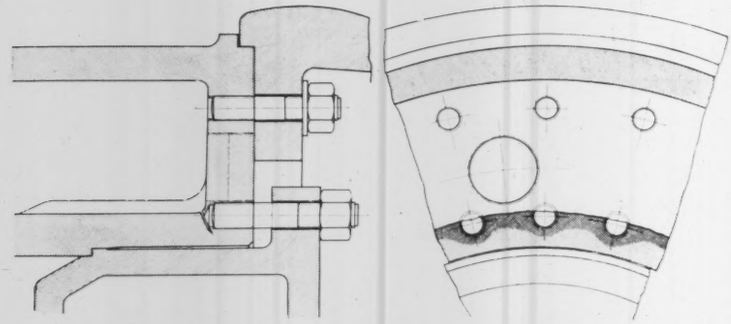

Fig. 5 Detail of Point of Frequent Breakage of One Piece Gas Engine Cylinders

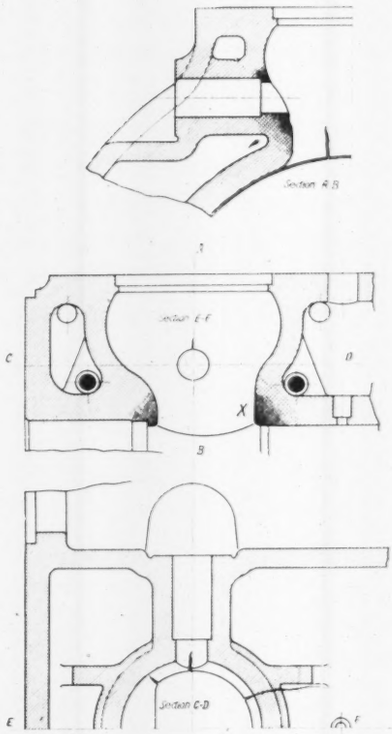

Fig. 6 Typical Locations of Fire Cracks in Places where Cooling is Impeded

This condition of stress can be compared with that existing in a bar being bent towards the inside of the cylinder. In the hotter layer the expansion being resisted causes compression stresses, and in the colder layers there will be tension stresses. As soon as cold mixture is admitted during the next suction stroke, the surface of the wall is cooled intensively. The inside layer of the wall cannot follow rapidly enough to cause the establishment of settled conditions corre-

sponding to this flow of heat. The mean temperature of the wall, and consequently its average expansion can only be affected very slightly during the first moment of internal cooling by the entering cold mixture. The innermost layer will be under strong tension on account of the sudden cooling. This " jumping " of the temperature acts upon the material in much the same manner as sudden flexure from the inside to the outside would. The inside layer of the wall of the combustion chamber, therefore, is exposed to the same kind of stresses as the outside fibre of a bar that is continuously bent in both directions by blows. The stresses which occur under these conditions are about proportional to the difference in temperature, the coefficient of heat expansion, and the modulus of elasticity, if, indeed, one can speak of such in the case of cast iron.

This is an extraordinarily unfavorable case of strain. Cases of strain on account of sudden changes of temperature are not rare, but these conditions are worst in the cylinders of gas engines, on account of the rapid succession of the changes in temperature. A mathematical deduction of these stresses is out of the question on account of the impossibility of obtaining even halfway accurate data on the distribution of temperature at any one moment over the different zones of the wall.

If we bear in mind, however, that a difference in temperature of 200 deg. fahr., when the expansion is restrained, corresponds to a strain of about 15,000 lb. per sq. in., we are surprised to find that cracks do not occur more often. The occurrence of a crack, which in the beginning is scarcely 1/8 in. deep, apparently relieves the strain to a certain extent and only the natural tendency of the cast material to continue to break together with the external mechanical forces causes the crack to open further. In most cases drilling and calking at the end of the crack will stop this. The timely discovery of the crack is, however, rather difficult, as it is not open after the wall is uniformly cooled.

The first step in combatting the occurrence of these cracks must reduce their real source, i. e., the differences in temperature, to an amount that is harmless. As the sudden changes of temperature are caused by the very nature of the gas engine cycle, these attempts must be confined to avoiding all irregular ignition and slow combustion, both of which increase the temperature of the cycle beyond the normal as well as the difference in temperature when the sudden change occurs at the beginning of the suction stroke. Furthermore, it is necessary to make the conductivity of the wall uniform in order to avoid accumulations of heat in the material. It is therefore necessary to avoid all accumulations of material. Passages as shown at *X*, Figs. 4 and 6, are also bad. Here accumulations of heat are the natural consequence of the imperfect conduction of heat being directed towards a center, the passage at the same time being very much exposed to the cooling action of the incoming air. Places like these are predestined to suffer from heat cracks.

The commonly used globe or onion-shaped passages for inlet and exhaust valves are therefore not suitable, and lately the form shown in Fig. 7 is very properly preferred. Here the valves are brought close to the inner surface of the cylinder.

In a much more effective manner than by measures of design, can the heat cracks, and in fact all cracks that occur in gas engine cylinders, be avoided by proper choice of a material, the constant of which (coefficient of heat expansion multiplied by modulus of elasticity) is less with the same tensile strength than in the case of cast iron. The less the expansion from heat, which is the real cause of the strain, and the more elastic the material, the less the strain.

Considering the enormous progress which metallurgical science has recorded during the past few years, a solution of this question of material should appear possible, and the more so, as nickel steel alloys

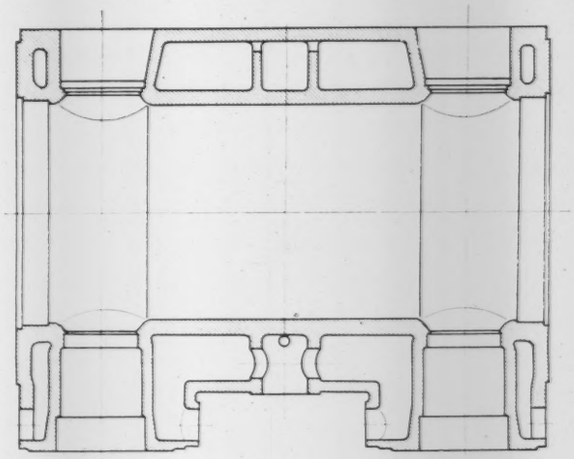

Fig. 7 Recent Design of One-Piece Gas Engine Cylinder that Avoids Globe-Shaped Passages to Valves

have actually been made for accurate rules, in which expansion from heat cannot be detected at all.

An investigation of the constants in question (coefficient of heat expansion multiplied by modulus of elasticity) upon which depends, according to the foregoing, the strain of the material resulting from uneven temperature, shows that cast steel is not a suitable material for gas engine cylinders. The larger expansion due to heat as compared with cast-iron and the very much higher modulus of elasticity causes increased stresses, while the strength of cast steel is not proportionately greater. Experience confirms this conclusion.

ON INCREASING THE OUTPUT OF LARGE GAS ENGINES

The principal task upon which the gas engineer is laboring incessantly, besides that of enhancing the reliability of the machine, is that of making it cheaper, partly by simplifying its construction, partly by increasing its output. At present it can hardly be imag-

ined that the gas engine can be made cheaper by making its construction simpler, now that the complicated valve gears have disappeared. Reduction of weight is not to be recommended. Until recently experience has demanded a continuous increase of engine weights. Economy in material would reduce reliability and length of life of the machine. The mechanism has been developed into standard designs, so that in this detail there is nothing to be saved.

Somewhat better prospects seem to be opened by the attempt to reduce the cost by increasing the output of the machine of a given size. Let us consider the equation for the power of the machine.

$$W = \frac{1}{A} H V \gamma a \eta_v \eta_t$$

in which

V = the swept volume (the factor which determines the absolute cost)

H = the heating value of the mixture

η_v = the volumetric efficiency

η_t = the total efficiency

γ = the number of suction strokes per second

A = the mechanical equivalent of heat

An increase of γ by increasing the number of revolutions per minute, is not practicable, at least not with less combustible gases such as blast furnace gases. The reliability of the machines would be lessened, not even considering the fact that the time available for the combustion of the mixture is too short and that therefore the losses on account of incomplete combustion would become too large. A comparison of the results of operation of gas operated blowing engines, which run relatively slow, and engines driving dynamos, proves that the former require considerably less repairs than the latter. Increasing the number of revolutions would increase the idle time on account of repairs, and a gain in output can hardly be expected.

The heating value of the mixture H is also determined by the minimum excess of air necessary for complete combustion, and there remain only the two factors of volumetric and total efficiency. It is conceivable that the total efficiency might be increased by increasing the thermal efficiency of the process. This, however, is dependent upon increase of the pressure and for this reason such a possibility must be eliminated. The volumetric efficiency can be increased in two ways: by cooling the charge and by increasing the pressure of the charge. The first method was proposed some time ago. It is not being adopted because in most cases the cooling water is warmer than the atmosphere and the in-coming gas. Besides, a large gain cannot be expected, as decreasing the temperature of the charge 10 deg. fahr. could only increase the output about 2 per cent.

The other method for increasing the output, which lately has attracted renewed interest, consists in increasing the pressure of the charge and simultaneous scavenging of the exhaust gases. In this manner a given suction volume of an engine can accommodate a larger weight of charge and greater output of power can be attained.

The original purpose of this method, which has been known in England for many years, was the avoidance of pre-ignition by scavenging the cylinder of what remained of the hot exhaust gases. It is the competition into which the gas engine has lately had to enter with the steam turbine, that has brought to the front the possibility of increased power output and consequently lower cost of the machine per unit of power.

The simplest method of realizing the scheme of scavenging and charging consists in closing the exhaust valve late and opening the inlet valve early. The time during which both valves are open is used for scavenging. In order surely to avoid loss of gas, the charging with gas is only commenced after the exhaust valve is closed. At the end of the suction stroke the mixing chamber must be cleansed of combustible mixture by scavenging (rinsing) with pure air, as otherwise backfires would occur at the beginning of the next scavenging period. Gas and air are brought to the machine under a pressure of about 3 lb. per sq. in. gage. On account of this increased pressure the weight of the charge is about 20 per cent greater than that of the normal method. Scavenging the combustion chamber also furnishes further space for fresh mixture. Experiments have shown a mean effective pressure of about 100 lb. per sq. in. In continuous operation, in so far as we can speak of such in experiments, mean effective pressures of 85 lb. per sq. in. can be reached.

Undoubtedly such results present much that is attractive, especially as the output can still be increased by further increasing the pressure, and as this would give to the gas engine the capacity for overloads which heretofore it did not possess in the same sense in which steam engines do. Experiments have also proved that these overloads can be had without an increase of the maximum pressure. This is done by reducing the compression.

In spite of the lower compression the heat consumption per unit of power was not increased. It seems that this result is explained first by better combustion of the charge which is not contaminated by the remains of the exhaust gases, and secondly by a decreased percentage of loss in the cooling water. The predominating influence can only be found by means of carefully measured heat balances which at present are not available. The increased temperature of the cylinder walls, which has been found thermo-electrically, has caused objections against continued operation with scavenging and forced charge. A certain justification cannot be denied to these objections. The *decrease* of continuous loads is the very factor that has contributed to overcome the difficulties of operation. To endanger regular operation by increasing the power

output must appear to be a dangerous experiment in just such cases where the equipment is insufficient and an increase is highly desirable. The disposition on the part of operating engineers to await developments, is easy to understand. The present satisfactory operation, which is the result of years of toil, is making these engineers justly conservative.

The danger is to be found in the fact that the increase of output on one hand is offset by a decrease on the other hand on account of the more frequent shutdowns for repairs. Besides these questions, which can only be solved by several years of experience, there are other difficulties in the constructive realization of this idea of increased output which have to be solved before it is proved to be practicable in sustained operation. In a word, there are many nuts to be cracked, before we can think of a practicable increase of the power output of four-cycle engines by means of scavenging and forced charge.

IMPROVING GAS ENGINE ECONOMY

The endless desire of gas engine builders to improve the economy of the gas engine, has lately brought to the front interest in the utilization of waste heat. According to experience, a blast furnace gas engine dynamo consumes in continuous service on the average about 16,000 B.t.u. per kw-hr. Of this amount of heat only 3412 B.t.u. is converted into electrical energy. Of the balance, 12,588 B.t.u., the mechanical, electrical, and radiation losses have to be regarded as unredeemable, as well as the energy contained in the unburned gases. The heat in the cooling water, about 4800 B.t.u., and that in the exhaust, about 5200 B.t.u. per kw-hr. is, however, available for a more or less perfect further utilization. The high temperature of the exhaust, about 880 deg. fahr., measured at the exhaust flange, makes possible its immediate use for the generation of steam in boilers, which have to be placed as closely as possible to the exhaust chamber. As a matter of fact, it is possible to obtain about 2 lb. of high-pressure steam per kw-hr. of the gas engine.

The utilization of the heat in the cooling water is not possible as directly as this. The further use of this heat means the generation of steam and this requires a considerably higher temperature than that customary today in large gas engines. Semmler suggested as long ago as ten years, that gas engine cylinders be cooled with water hotter than 212 deg. fahr., and that this water be put under pressure in order to avoid the generation of steam in the jacket. Evaporation commences only outside of the jacket, when the superheated water is conducted through a throttle valve into a steam drum. It may be easily understood that this "hot cooling" scheme has been regarded rather skeptically for a long time. About a year ago it was decided at the Rombacher Huetten Werke to try Semmler's cooling method on an 800-kw. tandem engine. The results in operation, which are available today, are entirely favorable. The hot jacket not only did not hurt the cylinder, but it caused apparently a softer and more quiet operation of the machine.

The use of distilled water in a closed cycle, and the considerably higher temperature of the outer cylinder wall, which causes nearly equal average temperatures of the inner and outer cylinder walls, are surely advantages which, if the favorable experiences last, merit more consideration than the recovery of waste heat. The amount produced is in the case of the engine mentioned, about 0.5 kg. of steam of low pressure per kw-hr. There is no doubt that this figure can be very much improved by designing the cylinders more suitably for this purpose, by careful insulation and by connecting the cooling water from the piston, which heretofore has not been used.

The results achieved in recovery of waste heat will be of different practical value for different types of blast furnace plants. Where there is a steam plant in addition to gas plants, it would be advantageous to shut down some of the boilers and substitute steam from the waste heat boilers by connecting them to the steam mains, because this steam can be produced almost without cost for attendance and for fuel, and therefore, as cheaply as is possible.

DISCUSSION

H. J. Freyn. Professor Langer devotes a considerable portion of his paper to the question of regulation of large gas engines and he points out in a very able and clear manner that of the two prevalent systems of regulation of gas engines, namely: by stratification of the mixture and constant compression versus throttling of gas and air and variable compression, the latter method has proved its superiority in every instance and from every point of view.

I can but heartily endorse every statement made by Professor Langer and while in my earlier career favored the stratification method I frankly changed my mind many years ago as a result of practical experience with engines regulated on both systems.

Abroad, the leading gas engine manufacturers have for a considerable length of time adhered to the stratification principle, although choosing the more rational form of attempting to obtain stratification by arranging their valve gear in such a manner that a certain quantity of pure air always *followed* the mixture.

In this system, therefore, only one chance for diffusion between gas mixture and pure air exists, with the result that operation at fractional load was reasonably satisfactory because the danger of formation of a bad mixture during the suction and compression strokes was not as great as it is in the system where a variable quantity of mixture is "sandwiched" between two layers of pure air, causing diffusion in two planes, as it were, on either side of the mixture.

It has been my experience that gas engines operating on the so-called stratification principle, while giving excellent results from full load to approximately half load, are not capable of maintaining regular ignition upon all piston

faces as soon as the load drops below approximately 50 per cent of the rated capacity.

The influence of this phenomenon upon regularity of operation, especially if alternating-current generators driven by such engines have to be operated in parallel, is very marked and it will be found that such power plants usually show excessive cross currents and "swinging on the line" at light load. This is not the case with engines regulated on the principle of variable compression and constant mixture, and especially with those where gas and air are throttled during the whole suction stroke.

Professor Langer has very ably and comprehensively proved along theoretical lines why this should be so, and he points out especially what provision must be made in the governor gearing to bring about the desired results, not only at full load but also at fractional load.

The point of "drowning" of gas engines in gas, raised by the author, is very well taken. Gas blowing engines which have to be operated at times at reduced speed are particularly susceptible to drowning. Gas blowing engines regulated on the principle of constant mixture and variable compression are better suited for slow speed operation, as was proven in many instances in Europe where large gas blowing engines could be operated for one hour at a speed of 19 r.p.m. with full pressure of 15 lb. on the blowing cylinder.

Without a single exception, German gas engine manufacturers several years ago abandoned the stratification method of regulation and a large majority have adopted the so-called "combination system," making use of the simplest method imaginable for throttling of air and gas, viz., by the application of so-called butterfly valves as throttling and regulating organs.

These engines are regulated in the following manner. From full load down, the governor acts first only upon the gas dampers with decreasing load, while the air dampers remain in their original position. Below about 60 to 70 per cent of rated load, the governor begins, through a toggle motion, to act upon the air butterflies as well. The toggle effect is so arranged that with further decreasing load, the air dampers act more quickly than the gas dampers, so that below a certain fractional load a perfectly constant mixture is admitted.

It will be seen that this combination method of regulation combines the advantages of both stratification and constant mixture regulating methods; at the heavier loads, practically constant compression is obtained, while at the lighter loads governing is performed on the constant mixture principle.

With reference to the subject of gas cylinders, I believe that Professor Langer's excellent exposition of the relative merits of cast iron and cast steel and of the one-piece vs. the split gas cylinder deserves the careful attention of both gas engine builders and users. Professor Langer's discussion of this question is very timely, because in this country the battle between the advocates of the one and those in favor of the other is still waging.

I have had an opportunity of studying these questions in detail during the last few years and I have come to the conclusion that Professor Langer is unquestionably right in his preference for one piece cast-iron gas cylinders fitted with hard cast-iron liners. Earlier difficulties with cracking of gas cylinders have naturally led manufacturers to look for a building material which could stand up better under the strains and stresses imposed by mechanical forces and temperature variations. In Europe cast-steel cylinders were tried several years ago with the result that breaks occurred after a much shorter time of operation than when cast-iron cylinders where used. I believe that a similar experience was had in this country.

Cast-iron cylinders in one piece can be made so perfect today that they will stand up very well. At the gas engine power plant at Gary, 140 one-piece cast-iron gas cylinders are in operation, 68 of which have been in service nearly five years. Of all these cylinders only one had to be actually replaced by a new one, although at the time of installation of these particular engines, the art had not progressed as far as it has today. It is true that a number of these cylinders show fire cracks and breaks in the counterbore, but repairs have been made and the cylinders are still in perfectly satisfactory operation.

One of the most important points to which by far too little attention is paid, especially in this country, is the question of the use of suitable cooling water. Very interesting experiments were made abroad to determine the effect of the accumulation of scale on the cylinder walls and it was found that the average temperature of these walls increased at an amazing rate with seemingly unimportant deposits of scale. I know of at least one installation where thermometers are inserted permanently in the inner cylinder walls reaching to within $\frac{1}{4}$ in. of the cylinder bore. The operator is supposed to watch these thermometers which, after the cylinder jackets have been thoroughly cleaned with wire brushes and weak acid solutions, show a gradual rise of temperature while operation continues. As soon as the thermometers show a temperature of 125 deg. cent. the engine is shut down and the cylinder walls are again carefully scrubbed and cleaned. In this particular instance the cracking and breaking of gas cylinders which had become a nuisance on account of its frequency, was entirely stopped.

Professor Langer has elaborated considerably on the question of the increase of output of large gas engines and improvements in gas engine economy. I have studied the latest attempts of European gas engine manufacturers to obtain an overload capacity of four-cycle gas engines by using the so-called scavenging and surcharging method. I have seen several installations abroad equipped with this system and I am familiar with tests made by Ehrhardt & Sehmer on engines furnished by them. They show that in spite of a material increase in mean effective pressure amounting to 25 to 35 per cent, no increase occurs in the initial pressure nor in the average temperature of the gas cylinders and other gas engine parts exposed to the high temperatures of combustion. This firm is prepared to give guarantees regarding the heat consumption of engines equipped with the scavenging and surcharging system which are not any lower than those usually given for ordinary four-cycle engines of equal capacity.

I cannot agree with Professor Langer's statement that engines operated on this principle are subject to a greater wear and tear than ordinary gas engines; the stresses and strains which the running gear and other engine parts sustain are due primarily to the initial pressure and not to the mean effective pressure. If we consider the main bearings, for instance, it will easily be seen that such a bearing will give no trouble as long as a film of oil can be maintained between bearing shell and shaft. The maintenance of such a film depends upon the amount of pressure per square inch

and not upon its duration; with lower initial pressure and higher mean effective pressure, therefore, these main bearings must give at least as good satisfaction as they are giving in ordinary four-cycle engines. As a matter of fact, the dimensions of pins, bearings, etc., of scavenged and surcharged engines have not been increased beyond those customary in ordinary non-scavenged engines.

The question of utilization of the exhaust heat of gas engines has had practically no attention in this country, and yet it is such an excellent and cheap means of increasing the usefulness of the gas engine and the financial returns from its application. I wish to refer in this connection to one of the best papers on the subject, which was read by Leon Greiner before the Liege Engineering Society about a year ago. Practical results are given which were obtained with an installation of such boilers in connection with blast furnace gas engines at the John Cockerill Works of Seraing, Belgium.

Referring to the competition between gas engines and steam turbines, I wish to call attention to my paper read before the American Iron and Steel Institute's meeting of last May, which is devoted exclusively to this subject and which proves with the aid of cost figures obtained in actual, commercial operation of large gas engine power stations in this country that gas engines operated on so-called "waste" industrial gases—an unfortunate misnomer which should be abolished as quickly as possible—are superior in commercial economy to any other known method of producing power.

F. Z. Nedden said that the present status of the large gas engine, both in Europe and in this country, is perhaps more considerably influenced by the introduction of surface-combustion boilers than implied in the paper. In this country we have very largely the use of natural gas, especially in the Pittsburgh district, which is very suitable for being used under Schnabel-Bone surface combustion boilers. One of these installed at the Shinningroove Iron Works, in England, is claimed to have given an efficiency of nearly 90 per cent, as compared with the efficiency of the ordinary boiler, which ranges from 65 to 70 per cent. That would mean that with the surface-combustion boiler the gases available in the Pittsburgh district would be able to produce one-third more power than at present. In other words, the cost of energy would in that district be reduced by about 20 per cent.

A great deal is said about the advantages of the Schnabel-Bone boiler which are naturally claimed by those interested in its introduction. Professor Langer's experiences with it would be of interest, if he would give some account of them.

To make his questions more specific, he said he would ask Professor Langer if it was true that the efficiency of the Schnabel-Bone boilers actually exceeded that of the ordinary boiler by about 25 per cent, and if that boiler was reliable in service;[1] also if the utilization of the heat of waste gases in the gas engine was possible by the Schnabel-Bone boiler?

R. H. Fernald. At a central plant in this country, built to utilize low-grade fuels at the mines, I ventured to criticise the fact that a steam plant had been constructed instead of a gas plant. The vice-president of the company said that he had wanted to put in a gas plant, but was forced to put in steam as he found no large gas producer units that would be available and satisfactory for an installation of the size contemplated. In other words, it seems to be a question of the size of the unit which is deferring the installation of plants of 100,000 to 250,000 h.p. directly at the mines. I would, therefore, like to hear from Professor Langer his opinion regarding the possible size of the large gas engine of the near future. The question, of course, arises as to what is a large gas engine. In 1900 a 500-h.p. engine was considered large. At the present time we have 5000-h.p. units. What is to be the large gas engine 10 years from now? The reciprocating steam engine was slow in developing. The steam turbine developed more rapidly than the reciprocating steam engine.

All are familiar with the relic in the yard of the General Electric Company at Schenectady—a 5000-h.p. unit which was one of the early turbines of this country. This was followed by an 8000-h.p. turbine and later by a 14,000-h.p. unit, and I understand that an order has recently been placed for a single unit of 30,000 or 35,000-kw. capacity. This steam turbine development has been very rapid.

If we are to install large central plants at the mines and develop electric current for long distance transmission we must have large gas engine units if producer gas is to compete with steam. A gas producer of 3000 to 4000 h.p. capacity in a single shell has recently been installed. The construction of the plant is so simple that the cost of manufacture should be low. If this producer meets the demand and proves to be a commercial proposition, there is a possibility of developing units of not less than 10,000 h.p. in a single shell (since these comments were made I understand that a unit of 75 tons capacity per 24 hours has been ordered), but gas engine units of a size to compete with large steam turbines are slow in developing. This central station at the mines is not pure theory. The few installations that have been made at the mines have attracted the attention of engineers and I understand that one of the large coal companies of this country is at the present time considering the installation of such a plant for the utilization of mine refuse. I was told recently that representatives of this company are in Europe seeking information relating to large by-product gas plants. I have also been told that the producer-gas interests are also alive to the situation and have sent representatives abroad within the past few weeks to study the question of large units. These large units seem essential if we are to utilize our fuel resources to the best advantage. I trust that Professor Langer can give us some definite information regarding the future of the large gas engine unit.

F. S. Giller. With reference to the point brought up about having gas-driven electric plants at the coal mines, I would like to ask whether gas engine sets, in their largest sizes, could compete with steam turbine sets, in their largest sizes, in the matter of cost of production and convenience of operation.

It is not easy to understand just what is meant by the author's statement that the gas engine is vastly superior as a fuel saver from the economic point of view. A concern handling a large power production undertaking does not consider either cost of fuel or first cost, except in their relations to the total cost of production. Undoubtedly the cost of fuel is a very important item in this total cost, but I believe that practically all of the other items, such as depreciation, repairs, rents, taxes, insurance, interest on invest-

[1] This question is very fully answered by G. Neumann's article, an extract of which appeared in the Foreign Review for January, 1914, p. 09, etc.

ments, etc., are higher for gas plants than for steam plants, and that together they usually constitute a greater argument against the gas engine sets than the high heat efficiency does for them. I have lately visited many large steam-driven and water-driven electric generating plants, and also the large gas-driven plant at Gary. At this last place, I could not help being struck by the great size of the generating sets in comparison with the sizes of corresponding turbine sets, the enormous foundations and buildings required by them, and the obvious need of a large staff of men to keep them in proper repair and operation. Undoubtedly the sets would be smaller if they were using richer gas, but I doubt whether, at the present time, the best gas engine set, working under its best conditions, can compete with the best steam turbine set, working under its best conditions. With regard to the future, the chance would seem to favor the turbine more and more, for the efficiency of the turbine is improving rapidly and continuously, whereas that of the gas engine is not so marked. The author speaks of the competition between the gas engine and the steam turbine, which lately has become very keen in Germany as well as in the United States. I am under the impression that the competition is becoming less keen and that the arguments are more and more in favor of the turbine. Several years ago, the Mond people in England were producing and distributing power gas on a large scale, but I believe their installations do not increase much, and that the progress made by gas plants generally during the last few years has not been anything like so marked as that made by the turbine, except that gas plants have been utilized in steel mills and other places where gas is to be had under unusually favorable conditions.

A comparison of the theoretical costs of production of electric energy by a large gas-driven plant and by a steam-driven plant of the same total capacity, assuming both of them to be situated at the coal pit and burning all the coal brought up from it, would be very interesting. I would like to ask whether such costs have ever been prepared and if not, whether the author considers that they would argue in favor of the gas-driven sets.

F. Z. Nedden, in reply to a question referred to the Humphrey pump recently installed in Chingford near London. The problem of using the Humphrey pump as a generator of electricity has been taken up by the Siemens-Schuckert Werke of Berlin. They are actively engaged in tests with the object of generating electricity by means of a water turbine driven by water raised by a Humphrey pump. The water after passing the turbine circulates through the pump again. So far nothing has been published as to the economy of the system. Such a plant would seem to be the proper spare for a low fall water turbine during periods of shortage in water. Instead of using a separate spare generator set driven by a steam or internal-combustion engine, the water would simply have to be pumped, by a Humphrey pump, from the tail-water back to the headwater and flow through the water turbine again, thereby saving expense for a spare generator and simplifying service.

The Author. Referring to the discussion by Mr. Freyn, while regulation by throttling the gas only will produce a smoothly running engine, I prefer to throttle air and gas simultaneously.

In reference to cylinders, cracked cylinders which have been calked have lasted a good many years and very many of them are still in use. It does not weaken or damage the cylinder if cracks are noticed soon and calked. The crack gives some relief to the lamina which is exposed to the highest temperatures and strains.

With regard to the objections in connection with the surcharging of the machine mentioned in the paper, I do not want to imply that the strains are due to the greater mechanical forces acting. There is no question that by reducing the compression pressure it is possible to work with the same maximum explosion pressure, at the same time having from 20 to 25 per cent higher mean effective pressure. The strains referred to are not caused by mechanical forces but by heating. In this matter I cannot draw on my own experience, but I have heard that the temperatures of the cylinders are increasing. This would mean an increase of strain in the cylinder walls due to the surcharging of the engines.

In reply to Mr. Nedden, I have no special information on the surface-combustion boilers. Generally it is said that the cylindrical surfaces on which the combustion takes place are filled with dust in a short time and put out of service. This, I think, is not a serious inference, since it should be possible to produce combustion cylinders at such a cheap price that it will be practicable to "scrap" them when necessary.

Professor Fernald asked about the size of gas engines. When we speak of large gas engines it means engines of 1000 h.p. and upwards. Double-acting engines of less than about 35 in. or 36 in. diameter of cylinder are not built at all, at least in Germany. The limit of the size, according to our experience there, is about 55-in. bore, by 6-ft. stroke. Tandem engines of this sort would carry a load of 3500 h.p., which means a twin unit of 6000 or 7000 h.p., about the maximum limit. This limit is not determined by shop practice or by designing, but by the impossibility of shipping by rail larger sizes of frames, cylinders and tie pieces.

I agree with Professor Fernald with regard to the production of electric power at the mines. Power can be produced at the mines for generating electricity and the current transmitted at 100,000 or 150,000 volts, which voltages I understand are being used in this country. Whether these big central stations will use gas engines or steam turbines is very hard to say; the question will probably be decided to a large extent by financial considerations.

While big units with piston engines are limited to 6000 or 7000 h.p., no limitations are given for the gas turbine, and this problem certainly represents the next advance to be made by the mechanical engineer.

In reference to waste heat boilers (in reply to a question), I cannot give the data on the necessary heating surface of these boilers. But it is not advisable to use too much of a heating surface, for it is necessary to discharge waste gases with temperatures of 200 or 220 deg., in order to prevent the condensation of the steam vapor in the exhaust gases and corrosion of the tubes, as sulphur is found in any of the industrial gases.

DYNAMIC BRAKING FOR COAL AND ORE-HANDLING MACHINERY

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Member of the Society

The knowledge that a direct-current electric motor can be operated as a generator and may therefore be used as a retarding device, as well as a driving means, is as old as the motor itself, and at first glance it appears strange that dynamic braking did not come into vogue until recent years. There are, in the writer's opinion, reasons for this which become apparent when the history of the art is considered. The earliest forms of coal and ore-handling machines were steam bridges or unloading towers, equipped with small capacity non-automatic tubs. In most cases these were lowered, with the hoisting engines acting as retarding devices. In cases where buckets were retarded in lowering by some sort of friction device no great amount of trouble was experienced, because there was not much energy to be dissipated. With the introduction of the automatic grab bucket the difficulties experienced with mechanical lowering brakes began to multiply, for the automatic buckets were naturally much heavier in proportion to the load handled than the small tubs which they replaced, and the duty imposed upon the lowering brakes was, therefore, greatly increased.

After the adoption of the automatic grab bucket the tendency was towards electrically operated apparatus, on which was used the retarding brake, already developed for steam plants. At first these sufficed and were considered satisfactory, but as bucket capacities increased from year to year, and the energy to be dissipated by the lowering brakes increased correspondingly, they began to show unmistakable signs of lack of ability to handle the duty imposed.

In analyzing the conditions above outlined, the underlying reasons are quite apparent: in small capacities the unit pressures on friction faces can be low, hence the wear is only nominal, and at the same time the radiating surface per watt dissipated can be sufficiently great to insure low temperature rise of parts. In large capacities, however, it becomes practically impossible to retain these proportions, on account of the apparatus becoming unwieldy. As a further disadvantage, the physical effort required to handle large friction lowering brakes is quite considerable, and it is axiomatic among designers of this class of machinery that prolonged high speed is not possible if the operator is called upon to exert any great effort.

Several builders brought out equipments on which brakes were controlled by air or hydraulic cylinders, with only pilot valves handled by the operator. These arrangements did not overcome heating difficulties, and in many cases were found unsatisfactory because of the lack of sensitiveness of control. When the operator handles friction brakes directly, he can, by sense of touch, determine when they are dragging to a proper degree, but when operated through a pilot valve, this sense is lost. It was natural, therefore, that the first 10-ton unloading machines to be electrified should have dynamic braking employed to retard the descending bucket. Manufacturers of bridges next adopted this form of control, first for ore handling and later for coal. It is now used extensively for ordinary traveling cranes, and from the present outlook it is quite possible that the mechanical lowering brake will be entirely obsolete within a few years.

On the earliest installations compound-wound direct-current motors were almost invariably employed, the shunt winding being deemed necessary to insure prompt building up of the fields. Later developments showed that series motors, the characteristics of which made them so desirable for hoisting, could be used equally well if their fields were temporarily excited just at the moment of releasing the holding brake and the excitation current cut off as soon as the machine built up as a generator. The cutting off of the excitation current is desirable, not only from the standpoint of current economy, but also from that of motor heating, for whatever exciting current is passed through the motor fields simply adds to the general heating of the machine. The use of series motors is also desirable from the standpoint of simplicity. Where compound motors are employed it is considered the best practice to leave the shunt field continuously excited and the heating consequent to the continuous excitation of these shunt windings is considerable.

Some form of holding brake must be employed in connection with dynamic braking, for while the motor acting as a generator can prevent the load from descending faster than a few inches per minute, it can never entirely stop the load, except through the aid of a mechanical holding device, which in some cases is electrically operated and automatic; in others manually controlled and non-automatic.

DIFFICULTIES ENCOUNTERED

One of the difficulties first encountered in connection with dynamic brake control systems was that the operator, who must necessarily be able to reverse his hoist motors in order to open his grab quickly and to start down without loss of time, would in many cases leave the power on almost all the way down and would in consequence race the hoist motor to such an extent as to throw out commutator bars and tear armature coils from their fastenings. Even if these things did not occur, the commutation at these high speeds was sure to be very poor, and motors were apt to flash over when the operator threw his con-

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troller back from the reverse power to the dynamic brake position. It can readily be seen that the closure of the dynamic braking circuit at a time when the armature speed was several times more than normal would cause the flow of a braking current of excessive value.

These difficulties led to the adoption of a control scheme which permits the operator to reverse the hoist motors when opening buckets and when starting to lower, and which causes the machine to operate as a motor until a predetermined speed is reached, when it automatically and without interruption of the circuit becomes a generator. This system was further perfected by the introduction of current relays in the braking circuit, with which the current of retardation can be limited to a reasonable value, and a value well within the commutation limits of the motor. As a further refinement control systems have been developed for those installations where the holding brake is automatically operated which insure the maintenance of the brake in the released position until the load has come substantially to rest.

Some plants installed during the development stage have not been as satisfactory as the purchasers had hoped. Against the later and perfected installations only two indictments can properly be drawn: (*a*) motors sometimes overheat; (*b*) machines have insufficient lowering speed.

Assuming the installation of a proper control system, the overheating of motors can invariably be traced to improper selection. Hoist motors cannot properly be selected on the basis of horsepower to be developed during the hoisting period. The service for which they are employed is so intermittent as to necessitate their selection by what is known as the root-mean-square method, or its equivalent. Generally speaking, motors required for a given hoist operating on a given cycle must have a thermal capacity which is greater by $33^1/_3$ per cent if dynamic braking is employed than will be required if the lowering of the bucket is accomplished by mechanical brakes.

Lowering speeds, possible with standard motors and dynamic brake control, never seem to be criticised except in connection with high-speed unloading plants. Generally speaking, it is not good practice to figure on obtaining lowering speeds which are greater than 200 per cent of the full load hoisting speed, unless special motors are employed, and it is a mighty good plan to figure on holding the lowering speeds down to one and one-half times full load hoisting speed if possible. The commutation of standard series wound motors of what is called the mill type (and this is the type which is generally used on coal or ore handling bridges) is not good if they are operated above 200 per cent of full load speed; furthermore the energy stored in their armatures becomes too great for rapid control when they are operated above this limit. If dynamic braking is to be a complete success on fast plants, it will be necessary for the designers of that machinery to select special slow-speed motors of the interpole type. There is little or no doubt but that with properly selected motors lowering speeds can be obtained with dynamic brake control which are just as high as those which are possible with mechanical lowering brakes. The apparatus will, however, be somewhat more expensive, and may be commercially impossible for that reason.

DYNAMIC BRAKING FOR TROLLEY SERVICE

So far we have considered dynamic braking only as applied to direct-current motors used for bridge hoist service. In some cases this form of control has been used in connection with trolley traverse motors, but for this service it is not nearly so well adapted; in the writer's estimation its fitness is questionable. In hoist service there is always a definite force (that of gravitation acting on the bucket) tending to run the hoist motor as a generator at all times when braking is required. On trolley traverse service the force driving the motor is exceedingly variable, being that of trolley inertia, and therefore proportional to the square of the trolley speed.

In hoist service dynamic braking is never required when the motor is rotating in the hoisting direction, and the reversal of the direction of rotation, before the motor is called upon to act as a generator, makes it possible for a series machine to be self-exciting without reversing the relation of armature and field, as is necessary on a trolley traverse motor when braking is to be accomplished while the motor continues to revolve in a given direction. The result is that a dynamic brake hoist controller is a much simpler and much more reliable piece of apparatus than a corresponding control for a trolley traverse motor.

The variable amount of energy to be absorbed on trolley control service and the comparatively small number of steps commercially possible make it impractical to stop by dynamic braking without making the bucket swing. Air braking, under the control of a standard railway type brake valve, providing, as it does, an infinite number of gradations of braking, is, in the writer's opinion, preferable for heavy duty, and the manually applied brake preferable for light service.

When a motor runs, say in a clockwise direction, it will be found that the best results will be obtained by setting the brushes a little ahead of the neutral point and thus giving it what is called the "motor lead." What is motor lead for one direction of rotation is "generator lead" for the opposite direction of rotation. Hoist motors can have their brushes given motor lead for hoisting and this will aid them to commutate properly while acting as generators during lowering. Any reverse power that they may be called upon to develop will be so small in comparison with that required in hoisting that their generator

lead for the lowering direction will not be found objectionable. The trolley traverse motors when used with dynamic brake control may be called upon to act either as generators or motors in both directions, and therefore cannot be thus aided. For this reason it is especially desirable to employ interpole motors when dynamic braking is used for trolley traverse control.

MISCELLANEOUS USES

In connection with car dumping machines there is no doubt but that dynamic brake control for the tipple motors is highly advisable, and so far the writer has heard no valid objections to its employment for this service. The lowering speeds demanded are never excessively high, one and one-half times full load hoisting speed invariably seeming to be considered quite satisfactory.

Dynamic brake control systems are sometimes employed in connection with car haul for pulling cars upon a dumper. In those cases where it is employed it has proved quite satisfactory. Braking is not ordinarily required when moving the mule car up the incline, and such braking as may be required in lowering is so small in comparison with the capacity of the motors necessarily employed as to make the problem an exceedingly simple one.

Of late years there has been a considerable number of bridges equipped with alternating-current motors and in some instances dynamic brake control has been employed in connection with those motors operating the hoists. The writer has not heard of any installations where this form of control is utilized in connection with trolley traverse motors.

USE WITH ALTERNATING CURRENT

A three-phase alternating-current motor of the slip ring type has to a large extent the characteristics of a direct-current shunt wound machine. Having these characteristics, it resists any force which tends to make it revolve above synchronous speed. A motor whose synchronous speed is 750 r.p.m., for example, will operate at about 720 r.p.m. when exerting full load torque. If a force equal to full load torque tends to revolve this motor above synchronous speed, the machine will develop a retarding force equal to the propelling force at approximately 780 r.p.m. On account of this characteristic, three-phase motors can be connected directly to the line for reverse operation and will prevent the lowering speed from exceeding the full load hoisting speed more than a few per cent. The motors cannot, however, be used to slow down the load, for only this one braking speed is available. On some installations attempts have been made to obtain perfect braking control by the excitation of the stator winding of the hoist motors from a source of direct-current supply.

When the stator windings are thus excited the motors act as generators and the currents set up in the rotor windings serve to retard the descending load. It has been found, however, that to bring the descending bucket substantially to rest, a very heavy exciting current is required in the stator winding. In fact, the exciting current required is so high that if prolonged for any considerable period of time, it will cause the winding to overheat. It has been necessary, therefore, to incorporate with these alternating-current dynamic braking control systems adapted to give graduated control, means for varying the stator excitation in proportion to the braking effort which the motor is expected to exert. There is one successful installation of this character with which the writer is familiar, but the maximum lowering speed it is possible to obtain is only one and one-half times full load hoisting speed. Above this speed the machine develops a tendency to run away. Then again, the machines are much slower in operation because the flywheel effect of the rotors in alternating-current motors is considerably greater than that of armatures in direct-current motors of corresponding capacity.

In conclusion, it would seem proper to state that dynamic brake control with properly selected motors is desirable on the hoist motion of all direct-current coal and ore-handling machinery; that the use of dynamic brake control in connection with trolley traverse motors is undesirable on both direct-current and alternating-current, and that the use of dynamic brake control is desirable in connection with alternating-current hoist motors, provided there is a variable excitation of the stator windings during the braking period.

REPORT ON HOISTING AND CONVEYING

A Brief Review of the Art of Hoisting and Conveying, with Discussion of Different Types of Apparatus, and Suggestions as to Equipment and Operation

A few years ago, the use of hoisting and conveying machinery was confined almost exclusively to the handling of ore and coal, while today there is hardly an industry that is not interested in the rapid and economical handling of material. High cost of labor and strong competition have increased the importance of this subject and made the material handling engineer an important industrial factor. Improvements in hoisting and conveying machinery have been most rapid where they could be applied without disturbing existing methods, but where radical changes were necessary, progress has been slower.

There are now before us far more complex problems that will require in their solution the coöperation of all interested, and your Committee, comprising engineers, manufacturers and users of hoisting and conveying machinery, desires to make itself of real service to the members of the Society as well as to the users of this class of labor saving machinery. To obtain the opinions and encourage discussions along these lines, it begs to submit the following report:

REVIEW OF THE ART OF HOISTING AND CONVEYING AT THE END OF 1912

The hoisting and conveying machine, in which the load after hoisting travels in a straight line, became important in this country in the year 1880. The earliest efficient commercial machines produced after that date were chiefly the invention of Alexander Brown of Cleveland, Ohio. Since that date the improvements have been rapid, particularly in apparatus for handling ore and coal and other bulk materials. The early machines employed buckets that were filled by hand. These have almost entirely disappeared and automatic grab buckets have taken their places. In these machines the winding machinery was installed at one end of the structure where it served to operate the hoisting and conveying ropes.

The introduction of electricity as a motive power is directly responsible for the development of the man-trolley machine. In the latter the operator as well as the motors both for hoisting and conveying are frequently carried entirely in the movable trolley.

The capacity of the hoisting and conveying machine has been greatly increased, for individual loads handled now reach 50 tons and over, and conveying speeds for lighter loads have increased to more than 2000 ft. per min.

The cableway as a hoisting and conveying machine made as rapid progress in its development as those employing rigid tracks supported by bridge structures. The span of cableways, that is the distance between two fixed towers, has reached 2400 ft. Conveying speeds of 3000 ft. per min. have been attained. The self-filling grab bucket and the self-filling scraper bucket are in common use on cableways today. The duplex cableways on power propelled steel towers as used in the construction of the Gatun Locks at Panama represent the highest development of the cableway art. The cableway has found a wide field of usefulness of its own, particularly where portability and semi-portability and long reaches are demanded.

Within the past two years the problem of package freight handling by mechanical means has received the attention of railroad and steamship companies, the manufacturers of mechanical handling appliances and public boards interested in terminal construction. Development has been principally along two lines, the overhead and the surface system, though a third, the conveyor system, has received some consideration. The conveyor system, while perhaps well adapted to certain special conditions, is believed to be not sufficiently flexible to meet the complex requirements of a typical marine and railway terminal.

The storage battery truck has been introduced and has found favor in several terminals. It takes the place of the old hand truck, making it possible for a man to travel faster and with a much heavier load, hence reducing the cost of transportation but not otherwise affecting the problem of hand labor. This truck has the advantage of easy introduction into old terminals requiring only a reasonably smooth floor. Like the hand truck, it can enter box cars and ships having side hatches.

In this connection may be mentioned the inclined elevator which has been introduced at a few marine terminals for carrying loaded trucks up a steep grade. The storage battery truck carrying a light crane has also been introduced, but up to the present time has not found a broad field of usefulness.

The overhead monorail system is being pushed by several manufacturers and is looked upon favorably by many interested in terminal development. It is not a new device but is rather the application of an old device to a new field, for it has long been used to a limited extent in industrial plants. Its introduction into the field of freight handling has resulted in some interesting improvements, especially in track and track switch systems.

Report of Sub-Committee on Hoisting and Conveying. Presented at the Annual Meeting, December 1913, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, 29 West 39th Street, New York.

Ingenious devices have been worked out for throwing the switch to the desired position and automatically placing a stop at the open track end by the approaching trolley. One system lately introduced avoids the use of any moving part in the switch steering mechanism carried by the trolley, enabling the operator to take any desired course through the switch without stopping.

An overhead system which has been used to some extent in Europe and which has its advocates in this country, employs what is termed the gliding switch. It has a curved switch member which slides along the main track. It permits a trolley to pass from the main track to the traveling cross track at any position. This switch is, as far as the main track is concerned, a derailing device. It is believed by the Committee that no installation of this type has been made on this side of the Atlantic.

Several installations of monorail systems for handling package freight have been made in this country, one at St. Louis of considerable size and another at one of the railroad terminals at Baltimore. These installations were made previous to 1912 and afford an opportunity to study the problem with a view to determining the type of terminal and layout of monorail system best calculated to produce the desired results of speed and economy.

An overhead monorail installation was made at the Baltic terminal, New York, in 1912, which handles freight both ways between vessels, warehouse, and a freight shed alongside a railway track. The system passes over streets and tracks at a suitable elevation so as not to hinder in any way the traffic on the ground level.

Another monorail system has been installed in a large wholesale warehouse in Los Angeles, Cal., which combines the handling of package freight from box cars to warehouse and thence for delivering by automobile trucks. A system of elevators permits the trolleys to be transferred to any one of five different floors, and extensions of the tracks over the street make possible the direct loading of automobile delivery trucks. These trucks are designed with removable bodies which are loaded in the warehouse and conveyed by the trolleys to the automobile trucks. Thus a shipment may be loaded on the fifth floor of a building and carried direct to the delivery automobile truck where it is placed intact without rehandling.

The removable bodies are equipped with small wheels so that the trucks themselves may be pushed about like ordinary hand trucks. A system of this type serves as a good demonstration of the saving in freight handling costs that could be made if railroads delivered freight to the address of the consignee.

In the present development stage, the storage battery truck and the monorail overhead system appear to be competitors for the field. Certain advantages and limitations of each are recognized. The battery truck as mentioned above will enter box cars and side doors of ships. It will go anywhere a smooth floor is provided, but it will only transport and will not hoist.

The overhead system involves greater initial cost. The trolley will go only where track is provided and will not enter box cars, but it will serve flat cars and may reach out over a ship, serving any hatch or the dock without regard to level as affected by stage of tide. It will hoist as well as transport, thus providing a means of transferring freight from one floor to another, and with the traveling cross track will serve areas and tier freight. The monorail trolley affords higher speed of travel than the battery truck. As it does not require clear floor space for a roadway, more floor is available for checking, storage, etc., and the capacity of the terminal materially increased. This increase in capacity should in a great measure, and perhaps fully, justify the greater outlay. It is probably a safe prediction that the two systems, the overhead and the surface, will supplement each other, though different local conditions may sometimes control.

Coöperation between railroads, steamship and dock companies, and machinery manufacturers is absolutely essential to the best results in the development of devices for the mechanical handling of freight. Modifications and improvements in the organization and management of terminals must of necessity be made coincident with the installation of the hoisting and conveying appliances in order that such machinery may best serve its purpose.

In the past year the mechanical handling of lumber has received considerable attention. This is particularly true on the Pacific coast, where extensive preparations are being made for handling the large increase in business that is predicted will result from the opening of the Panama Canal.

The unit system of handling lumber is becoming more and more general. By the unit system is meant the sorting and stacking of lumber in uniform units which may be separated by skids or chocks, and one unit or package handled at a time. Modern hoisting and conveying appliances are equipped with automatic grapples so that these units may be picked up or deposited by the operator in the hoist. The units will range from 3 to 8 tons.

In this work the monorail man trolley has been a recent and important development. The locomotive crane has also found a field in this branch of industry and in some cases the locomotive crane of the portal pier type is needed, so that freight cars may pass between the legs of the cranes and be loaded and unloaded by it. This type of crane is designed to travel along the face of the dock for handling lumber directly to and from boats, and by means of a transfer table the crane may be switched to branch tracks for the handling of lumber to and from storage piles.

Probably the most radical development in the lum-

ber handling industry is that which the C. A. Smith Lumber Company of California have undertaken. The unit system is employed and the lumber is handled by various types of cranes. Cantilever cranes are used on the dock face for loading specially constructed vessels for the trade, which enable the large 8-ton units of lumber to be stowed intact. This means of direct handling of large units, and the development of special vessels to facilitate handling most nearly approach the history of the development of the coal and ore handling business on the Great Lakes.

We find also that during the year 1912 portable cableway log skidders have been produced and many have recently been installed in the mountain regions of North Carolina and Virginia. The features of this apparatus are: (*a*) the power plant is entirely mounted on a special railway car equipped to be coupled into a train of cars and shipped anywhere on a standard gage railway; (*b*) the car carries, besides the operating machinery, boilers, etc., a tower which will clear the tunnels of the railroads. A portable tower is added when the machine arrives on the logging railroad and a steel portable spar, which comprises the head tower of the cableway, is raised when in use and lowered when moving. A tree is used for the tail tower. Spans of 2000 ft. have been successfully employed bringing in logs from inaccessible places and thereby reducing the cost of logging by the saving of railroad building.

Two novel forms of cableways have reached their perfected stage during the year 1913. Both of these are for use on the high seas, one for trans-shipping coal, ammunition and supplies to warships in mid-ocean under headway, and the second for trans-shipping persons from a wreck to a life-saving ship.

The apparatus for coaling at sea has been under development for over ten years but not until the last year, and since the newly developed automatic tension engine has been added, can the marine cableway for coaling at sea be regarded as a complete solution of the problem. During recent tests at sea a collier, while rolling 20 deg. in a driving storm, trans-shipped 83 tons of coal in an hour to a battleship 400 ft. astern of the collier while both were proceeding at a speed of about 7 knots.

The life-saving machine comprises the old-fashioned breeches buoy apparatus, in common usage along the coast, in connection with a small sized automatic tension engine serving to wind in and pay out the main supporting cable or hawser serving as a trackway for the passage of the breeches buoy from ship to ship.

The year 1912 also marked the completion of an extraordinary group of four cableways employed for building the Tunkhannock bridge on the Delaware, Lackawanna & Western Railway. The chief novelty arises in the employment of a center tower 230 ft. high serving as a tail tower for the cableways in line. A further novel feature of these four cableways is in the equalizing apparatus to save the strains upon the guys of the central tower. The hoisting speed is 200 ft. per min. and the conveying 1800 ft. per min.

During the year there have been installed on the Sag Channel, a branch of the Chicago drainage canal, three different types of drag line excavators consisting of an elaborate crane with a boom 100 ft. long, capable of digging, hoisting and swinging, and dumping at a point 200 ft. back from the center of the canal. These long arm excavators are reported as showing a capacity of approximately 50,000 cubic yards per month, working 24 hours a day.

During 1912, the conveyor field was marked by little change except plants with larger capacities than in the past both in chain and belt conveyors.

One development which is of interest was the successful demonstration of the possibility of storing material in open piles on the ground and withdrawing same by tunnel conveyors. The plant in question handled 6-in. limestone which was put into storage by a 40-in. belt conveyor equipped with an automatic tripper and carried by a steel structure. The concrete tunnel under the pile housed a 44-in. belt conveyor and duplex gates in the roof of the tunnel allowed the stone to flow to the belt by gravity. There were successfully handled through a single duplex gate 1300 tons of stone per hour. This type of storage costs about half of the same capacity in bins and in this case replaced bins on a dock, the stone from open storage being carried to the vessels by 44-in. belt conveyors. Seven thousand tons were loaded without difficulty in six hours. This scheme of carrying a large storage on good ground, thus reducing the cost of the dock, is a distinct step forward, particularly where rapid loading is required and where the supporting of heavy loads involves expensive dock work.

The second important development in this industry is the extension of the use of conveyors in preparing copper blast-furnace charge. The old methods of spreading the charge on the ground by barrows or by cars into bins was inaccurate and expensive, while the conveyor method is automatic and a continuous sample being taken, the exact chemical contents of the charge are known. This improvement has reduced the cost of preparing the charge from 10 to 15 cents per ton. Two large installations in Arizona during 1912 involving an expenditure of nearly $400,000 are evidence of the fact that smelter engineers are recognizing the importance of using improved automatic machinery.

Data. As there are few accurate published data concerning capacities, weights, power formulae, etc., of conveyors and elevators your Committee would urge the engineers in this field to present such data through the Society. These data will be of inestimable value to the engineers designing plants, enabling them to choose the proper type of conveyor and to pass intelligently upon the designs submitted.

These installations do not by any means cover the field of development, and the Committee invites members to forward brief descriptions of other interesting and novel installations in the field of hoisting and conveying.

RECOMMENDATIONS AND SUGGESTIONS

Boilers. It is not the desire of the Committee to decry the formation of stringent boiler laws, but it urges that if state and city boiler laws were standardized it would reduce the cost and permit the shipment of a boiler from state to state. It would further make it possible to carry boilers in stock ready for quick shipment. This subject has been considered by the American Boiler Manufacturers' Association at its New Orleans meeting, March 1912.

At present we have a national uniform law pertaining to marine boilers, their construction, inspection, etc. All boilers used in navigation and on navigable waters of the United States come under the Steamboat Inspection Service of the United States Government, with headquarters in Washington. Facts have proved that this national uniform law has been good, and under it there have been few accidents.

Locomotive boilers by force of circumstances come under the jurisdiction of the United States Government through the Interstate Commerce Commission. This commission is divided into districts, and the inspection is uniform.

The state of Massachusetts has an excellent boiler law, and Ohio has just adopted a similar one. Chicago, Philadelphia and Detroit each have their own ordinances regulating boiler construction, all with the result that boilers built to the requirements of Chicago might not pass inspection in other cities.

Your Committee offers the suggestion that if the influence of The American Society of Mechanical Engineers is brought upon the proper authorities, improvements in standard boiler laws must be obtained.

Electric Equipments. The uniformity of all laws of this character is essential both to the builder and the buyer, and we again urge that steps be taken by the Society as a body, to further reforms in this direction.

Safety. Your Committee urges that much can be done by providing better protection of human life, and deplores the great number of accidents that have been caused in connection with the operation of hoisting and conveying machinery. The chief reason for neglect of this phase of the art is that purchasers of hoisting and conveying machinery have not been willing to recognize such additions and refinements where these have added to the cost of the machines. It urges that the question of safety to human life be conscientiously considered by manufacturers, engineers and purchasers.

Your Committee recommends that ladders be abandoned, where possible, and stairways with hand rails substituted; that all platforms and walks be provided with double hand rails, toe boards, etc. Where ladders are unavoidable they should be enclosed by lattice work or bars to prevent employees from falling in case of losing hand or foot holds.

Foundations. Much blame has been put upon builders of this heavy hoisting and conveying machinery on account of inadequate foundations. Builders of hoisting and conveying machinery seldom design the foundations for their machinery. The design of foundations for big installations comes within a field of foundation specialists who, if employed by purchasers, would obviate many difficulties which might arise.

Many docks and storage areas bordering on rivers and lakes, designed for carrying large quantities of bulk materials, have not received the attention in this particular that they should. In many cases expensive concrete dock walls and piling have been pushed out into the rivers by the pressure of the loads carried on the area in the rear. This is particularly true in stock yards around the Great Lakes.

Hoisting and conveying machinery should be designed to take care of a reasonable amount of distortion, but it is not reasonable to expect that these massive structures, many of them weighing over a million pounds, can have an unlimited elasticity as to distance between supporting rails. Disregard of suitable foundations results in broken wheel flanges, distorted structures and increased power for propulsion.

Depreciation. Your Committee finds that some of the largest and most expensive hoisting and conveying machines installed some ten or twelve years ago, are today showing signs of weakness. This indicates that the manufacturers and designers did not anticipate the use (and abuse) that this class of machinery was to receive. Many machines have been designed, sold and guaranteed for a certain capacity, which later developed capacities nearly double that originally contemplated, and carried loads far in excess of those originally estimated. Users do not hesitate to increase the weights of buckets and loads to such an extent that factors of safety are dangerously reduced.

Such use helps to depreciate the machines and endangers human life. Purchasers frequently fail to appreciate the great damage to structures caused by the passage of loads at high speed from rail end to rail end. Well designed and efficient machinery, having due regard to human safety and the reduction of costs of upkeep, will many times repay the purchaser.

Wheels. Your Committee finds that the data concerning track wheels for heavy hoisting and conveying machinery are most limited, both for rolled steel or chilled cast-iron wheels. The Committee invites papers bearing on this important subject.

Brakes. In many hoisting and conveying machines in the past, working to their utmost capacity, the brakes showed need for improvement. Some showed

inadequate provisions for the dissipation of the heat developed, others were too short lived. It is no small undertaking to lower a 20-ton load at the rate of 350 ft. per min. once every minute. The dynamic brake has recently taken a prominent place in the control of loads.

Wire Rope. Your Committee urges the importance of the selection of wire ropes and the design of structures to obtain the greatest life from ropes in service. The transportation of heavy loads together with the limited space for the installation of the operating machinery produces elements which are most destructive to the wire ropes. Ropes become an expensive factor in the operation of machinery of this class. A valuable paper on this subject was recently read before the Institution of Mechanical Engineers of Great Britain, and a digest of it should be before designing engineers. The durability of wire rope is of great importance to all users of hoisting and conveying machinery, and any paper treating exhaustively of this subject would be welcome. Such a paper should bring out the relationships between the diameter of the rope and the sheave over which it is to travel, the diameter of the individual wires in the rope, as well as the relationship between the diameter of the rope and the angularity of the bend when working over a sheave. It would be most desirable to obtain proper specifications for wire ropes for use in hoisting machinery and suitable tests to establish its values.

Ethics. Your Committee urges that the drawing plans and specifications prepared by any engineering concern are the property of the concern producing them, and holds that buyers should receive such in confidence, decline to exhibit them to others, refuse to permit them to be copied or used by any (but the owner) for purposes of construction.

It recommends among engineers that a uniform clause be embodied in all proposals requiring the return of blueprints, drawings and specifications to unsuccessful bidders, and furthermore, that all information submitted for consideration be regarded as the property of the manufacturers and be treated in confidence.

Pirating of ideas is regarded by the Committee as dishonest, and in the end works to the detriment of the buyer as well as to the engineering firms, for it is clear that the most efficient machines are likely to be produced by the mind that created them rather than by the manufacturer animated purely by the desire of pecuniary profit.

The history of nearly every important improvement in the development of the art of hoisting and conveying shows that the engineer freely laid his plans and ideas before the prospective user, both being masters in their own particular field. In order to develop what is required by the producer, complete co-operation between the two is of the utmost importance.

Your Committee recommends to all the departments of the United States Government that in asking for proposals, they insert in the invitation that the drawings and blueprints, and all data of a confidential nature shall be retained in confidence and returned to unsuccessful bidders.

Respectfully submitted,

R. B. Sheridan, *Chmn.*
C. K. Baldwin
Alex. C. Brown
O. G. Dale
P. J. Fickinger
F. E. Hulett
Spencer Miller
A. L. Roberts
Harry Sawyer

Sub-Committee on Hoisting and Conveying

DISCUSSION

Spencer Miller in presenting the report for criticism asked if it were too voluminous; should it be further condensed? Should it be elaborated? Should it be illustrated? He said the committee desired to be of real service.

William Kent said he desired to see the report extended and illustrated, and that the committee should take one year or two years, if necessary, to do it. The monorail conveyor should be considered and facts regarding it incorporated in the report: what were the limitations of the monorail conveyor, where it should be used, and what were the economical loads. Illustrations showing actual installations should be given, with sizes of bearings, troubles from lubrication, friction, etc. Sketches of the various kinds of monorail conveyors should be shown with the defects of each. This applied to the belt conveyor also.

The committee should then take up the problems yet to be solved in conveying, such as getting packages out of the hold of a steamer and putting them into a warehouse in West Street, or the Bush Terminal, or some other place. That whole problem was now being handled in the most crude manner, and if the committee would take up the matter, they would perform a great service for commerce and engineering.

D. M. Myers was pleased to see the reference in the report to the matter of uniform boiler inspection, and hoped that everything possible would be done by the Society to forward safety in boiler manufacture and inspection.

Spencer Miller was obliged for Mr. Kent's suggestions as to the field in which the committee could do further work, and said it would go as far as it could.

BUSINESS TRAINING FOR THE ENGINEER

Abstract of Address by Dr. Alex. C. Humphreys at the Philadelphia Meeting, February 9, 1914

A meeting of the members of the Society in Philadelphia in coöperation with the American Institute of Electrical Engineers was held on the evening of February 9, at which there were addresses and a general discussion on the subject of Business Training for the Engineer. The principal paper of the evening was by Dr. Alex. C. Humphreys, Past-President of the Society. Dr. Humphreys said that this country is facing many problems which must be solved wisely if our government as a government of the people, for the people and by the people, is to persist. A large majority of these problems have to do with public utilities and the industries in general where expert advice is required. They would not now be so threatening if the members of our profession had better appreciated their responsibility in connection with them and had been diligent to equip themselves to meet this responsibility. So many engineers have failed to realize this situation or have been disinclined to consider the business features of engineering, or even to familiarize themselves with the principles of accountancy and business administration, that it is difficult to educate our legislators and laymen in general as to the legitimate claims of investors whom engineers are called upon to represent. No doubt it is also in part due to these causes that so few engineers are appointed on public service commissions, a service for which the broadly trained engineer is peculiarly qualified.

Dr. Humphreys asserted that he had had to meet many objections to his plans to give to engineering students instructions in the fundamentals of business practice. During his presidency of Stevens Institute of Technology he had developed a course in business methods in which the student had to take up not only the business features of engineering practice as a theory of study, but before they could graduate they had to pass an adequate examination in the elements of accountancy, depreciation, the accountancy of depreciation, analysis of data, investigations, estimates, contracts and appraisals; but they also had special lectures on the law of contracts, patent law, employers' liability and workmen's compensation, shop cost, the elements of banking and the like. While no such course could give the engineer anything like a complete equipment on the business side of engineering, this could also be said as to the curriculum in its every feature. The engineer student must study in the school of experience and unless he did he must remain as a humble follower in the ranks of his profession.

This meeting was briefly reported in The Journal for March. The complete report may be consulted in the rooms of the Society, 29 West 39th Street, New York.

Dr. Humphreys further said in part: We are all prepared to admit that an engineer should be qualified to make a correct and fully inclusive estimate of cost of construction and installation; and most of us will admit that he should also be qualified to estimate the results in dollars and cents to be reasonably expected from his work as a designer and constructor.

How can an engineer best check up his estimates as to construction and operation? By comparing the established facts with his estimates. Can he do this if he is not qualified to take full account of business conditions in his estimates? And can he do this if he is not qualified to analyze correctly the statements as compiled from the statistical books and the books of account? My answer is that he cannot make such comparisons correctly and completely, for two reasons:

a he is likely to omit from the comparisons items of cost for which he assumes he is not wholly or in part responsible

b he is not sufficiently familiar with the language of accountancy to be sure of the value of the comparisons made by others for him.

The best means at the command of the engineer to qualify himself further for the making of correct and completely inclusive estimates is the comparison between his estimates and the actual results obtained. Ordinarily the engineer makes such comparisons, but the question is, Are they made completely unless the business features of the enterprise are fully included?

In order to meet the requirements which are daily becoming more pressing, the engineer of today must not only be able to obtain good results in construction and operation, but to record those results so that the records are self-explanatory to the man competent to analyze them. This is the test under which many an otherwise competent engineer fails. It can hardly be denied that the man who does so record, analyze and compare his results is seldom an extravagant constructor or operator. If the engineer is to record his final results accurately and completely, so that those results can be understood by others to whom he may be responsible, there is only one language which is universal, and that is the language of accountancy.

As to the value of accountancy to an engineer, let us suppose that he is called upon to examine into the value of a manufacturing property, and that there are presented to him a ledger trial balance, a profit and loss statement, and a statement of assets and liabilities. It goes without saying that if he is to make an authoritative report he must understand how these statements are produced and how they are related to each other; and this he cannot do without a knowledge at least of the principles of accountancy. It may be replied that in this work the engineer can be associated with an accountant, or that his responsibility is confined to the strictly engineering side of the proposition. Then the accountant must have a sufficient knowledge of the

practical or engineering side of the business to ensure that the report as a whole shall be conclusive. This puts the engineer in the subordinate position, a position to which he too frequently seems willing to submit. The fact is that many such reports fail to coördinate because there is no such combined knowledge on the part of either the engineer or the accountant.

A knowledge of accountancy is particularly convenient in one direction, if not actually necessary, namely, in differentiating between repairs or renewals and extensions or improvements. If under the heading of repairs or renewals, extensions or improvements are charged too liberally to operation, the capital accounts may be unduly written down. On the other hand, if repairs and renewals are charged to extensions, the statement of profits is misleading and the capital accounts are unwarrantably expanded. The ability so to discriminate is a necessary qualification in the engineer-manager.

This brings me to the question of valuation of properties, which is becoming such a burning question today. Probably no one element in this subject of valuation is as important or as difficult as that of so-called depreciation. The engineer may consider that he can have a sufficient understanding of the subject of depreciation without a knowledge of the principles of accountancy, but I am confident that no man can be in a position to meet effectively the arguments of others in regard to depreciation, estimated and actual, unless he has a knowledge of the principles of accountancy. If I may judge by my experiences, it seems to be almost impossible for the man without this knowledge to appreciate that there is a sharp distinction always to be drawn between estimated depreciation and actual depreciation.

It is a fact to be deplored that not a few engineers have helped to create the confusion that now exists with regard to the difference between estimated and actual depreciation. Recently, in discussing a paper on this subject, presented before the American Society of Civil Engineers, I expressed regret that the term "depreciation" had ever been employed in this connection, and I suggested that if we would cultivate the use of the term "final renewals" instead, we should be less perplexed. Undoubtedly depreciation to accrue, namely, the cost of final renewal of plant or part of plant in consequence of physical decay, obsolescence, or inadequacy, should be covered by estimate as far as possible, so that the burden of the loss can be more evenly spread over the years of service of the plant to be renewed. In any case the cost will fall on the business, but to enable us to determine year by year what are our actual profits as differentiated from the profits which are apparent on the surface, we must take into account all accruing gains, and especially accruing losses. Otherwise we may pay out as profit that which has not been earned, and we may permit to accumulate a financial burden which we may be unable to carry when the day arrives for the final renewal of the plant or part of plant.

But in a rate-making case this does not necessarily involve the proposition that the plant as a producing agent is reduced in value to the extent of the final renewal reserve, nor does it, in my opinion, furnish the slightest warrant for adding the amount of this reserve in valuing the property as a going concern. The question of deduction from appraisal of cost new of plant in a rate-making case must not be confounded with the same question in valuing a property in connection with change of ownership. In a rate-making case the liability for final renewals remains with the present owner. If the valuation is made for purchase and sale, that is, in connection with change of ownership, the seller should make allowance to the buyer for the *liability* the latter assumes for the cost of final renewal; but even this is not necessarily the amount shown in the final renewal reserve. In fact it would be remarkable if there were such an agreement in the case of a well managed business, for as prudent operators, we should be on the safe side in estimating all of our certain, probable, and possible, accruing losses; and this can only be done with respect to final renewals of plant by making certain assumptions as to length of service, character of maintenance, chances of obsolescence and inadequacy, and methods of accounting to be followed.

The foregoing relates to what is sometimes known as "estimated depreciation," namely, the accruing loss for the final renewal of plant in addition to the current losses for maintenance; now as to "actual depreciations":

If, at any given time, it becomes necessary to value the plant itself, we have the plant before us; we are informed as to present demands made upon us by the business. We are able, therefore, to determine whether the plant is adequate or inadequate as to capacity, and are able to determine its condition as to obsolescence. Why then, in trying to determine the present actual condition of the plant, with the plant and business records before us, should we depend upon an estimate made perhaps years before (or some previous year) as to what would be the condition of the plant in years to come? The actual facts can be determined only by an adequate examination of the plant by those competent as constructors, as operators, and as administrators.

Coming back to the question of accruing depreciation, or reserve for final renewals, there would be no necessity to make any estimate thereon if we were convinced that the plant year by year is having spent upon it, not only for repairs and current renewals *but for final renewals*, an amount which keeps the plant up to its full original value; that is, if the asset value is being maintained as a whole. For instance, suppose that the ties of a railroad are found to have an average

life of ten years, and it is also found that, taking in the main line and all subordinate lines, about one-tenth of the ties are replaced each year; then there is no need to charge up anything for accruing depreciation on the ties as a whole because the average final loss is currently being met.

This gives an opportunity to point out a serious error in rate-making cases, as made even by engineers of reputation, in confounding accruing depreciation as estimated in connection with loss and gain account, and actual depreciation in connection with a valuation. In the case of the railroad ties referred to, certain engineers of repute have claimed that in this case the ties in service would have a remaining average life of only five years and therefore 50 per cent should be deducted from the cost new to cover depreciation. This spells confiscation as far as that part of the plant is concerned; and in this case I hold that if such a claim is allowed we should be permitted to introduce in the estimate of cost new a like amount as an overhead charge, for the reason that this 50 per cent is thus declared to be a necessary loss in connection with the construction and maintenance of the plant.

This leads to a very brief consideration of so-called overhead charges, items wholly or in part which too often the engineer fails to include in his estimates. By some the items of omissions and contingencies are considered as overhead charges. I consider them items of construction, for while we may be able to estimate these items of cost accurately, we may be sure that there will be items of cost under these two headings. There never was constructed a plant of any size, which, when it was finished, did not contain parts which were not included in the original estimate. Furthermore, we must be prepared for contingencies in connection with almost any construction of magnitude. And yet there are so-called experts who claim that in valuing a plant as it exists, if we make an inventory and put against each item in that inventory the cost of reproduction, the cost as a whole is covered. No man who has had experience as a constructor and who will look back upon and analyze his experiences can honestly endorse such a claim. To commence with, no such inventory is ever absolutely complete. But suppose it to be complete as far as possible, no such inventory would ever include all the items which have necessarily gone into and have been covered up in the construction of the plant.

There are other items which must be included in the final cost, call them overhead charges or by any other general title. These may be summarized briefly as follows: Preliminary expenses and surveys, interest and taxes during construction, engineering and inspection (strangely enough, an item not infrequently omitted by the engineer), business organization during construction, fire and casualty insurance, cost of development, cost of financing.

NECROLOGY

EDWIN M. CORYELL

Edwin M. Coryell was born in Brooklyn, N. Y., September 25, 1847, and was educated in the public schools there. After three years as apprentice and draftsman, in 1869 he started out for himself as mechanical engineer, patent attorney and draftsman in New Haven, Conn. Two years later he secured employment at the Bessemer Steel Works, Troy, N. Y., where he came under the personal direction of Alexander L. Holley and was fellow draftsman with Allen Sterling. He served as draftsman at the Providence Steam Engine Works as well as on the Brooklyn Bridge, and from 1878 to 1879 was draftsman with the New York Gas Light Company. For the last 34 years Mr. Coryell had been connected with the A. S. Cameron Steam Pump Works, first as draftsman, then as salesman, assistant superintendent, superintendent and finally as consulting engineer. During that time he invented more than 200 patented devices for pumps and other machinery. He died suddenly on March 23, 1914.

WALTER LAIDLAW

Walter Laidlaw was born in Scotland in 1849. In his youth he served an apprenticeship of four and one-half years as machinist with James Sheil, maker of machinery for the manufacture of Scotch-Tweed engines, water wheels, shafting and gearing. This course was supplemented by one and one-half years service as an "imperial erector" with Caird & Company, shipbuilders and engineers, Greenoch, Scotland, in which position he was engaged in the erection of first-class ocean steamships. He next entered the engineering department of Trinity House, a body which has official charge of the lighthouses of Great Britain. He served as engineer and chief engineer for ten years and worked in this most interesting period of lighthouse development shoulder to shoulder, first with Prof. Michael Faraday, who was scientific advisor to Trinity House, and later with his successor, Professor Tyndall; he also enjoyed the acquaintance and at times coöperation of Lord Kelvin in some of these developments. While in this service he drew the specifications and purchased the first direct-acting generator ever used for lighting, which he installed and for a while operated in the lighthouse at Lizard Point, where it is still in satisfactory operation as an auxiliary.

Mr. Laidlaw came to this country in May 1881, and entered the employment of the Lane & Bodley Company of Cincinnati. After two years with this company, he accepted a position as constructing engineer with the Procter & Gamble Company of Cincinnati, to design and construct the extensive new factories which they were then preparing to build at Ivorydale, near Cincinnati. Mr. Laidlaw remained in charge of this work until 1887, and had the satis-

faction of bringing to completion one of the most complete manufacturing plants in this country.

In 1887, with the completion of the Ivorydale plant, Mr. Laidlaw assisted in organizing the Laidlaw & Dunn Company, afterwards the Laidlaw-Dunn-Gordon Company of Cincinnati, manufacturers of steam pumping and hydraulic machinery. With the formation of the International Steam Pump Company in 1899, Mr. Laidlaw was continued as manager of the Cincinnati plant. In 1908 he became general manager of the Snow Steam Pump Works at Buffalo, N. Y., and in 1909 a member of the executive committee of the International Steam Pump Company, making his headquarters at the head office, New York City. Shortly afterwards, he became secretary, and later director, of the International Steam Pump Company, and vice-president of the Laidlaw-Dunn-Gordon Company, positions he retained until the time of his death, March 25, 1914.

During the latter part of his life Mr. Laidlaw realized the full development of his engineering abilities, and became greatly interested in the technical education and advancement of young men. It was largely through his efforts that the Ohio Mechanics Institute was placed upon a solid basis and began its successful expansion. He served at one time as president of the institute and recently stated that one of the most pleasant memories of his life was his privilege, in that capacity, of awarding the diplomas to the young graduates in whom he had taken so much interest, and seeing them started upon their life work.

Mr. Laidlaw was Manager of the Society from 1905 to 1908, and was a member of the Engineers Club of Cincinnati, Engineers Club of New York, Manufacturers Club of Cincinnati, Cincinnati Chamber of Commerce, and of the Board of Managers of the Society for the Promotion of Industrial Education. He was a man of widely varied interests and activities, but bringing to all of them a degree of calm and far-seeing judgment, tolerance and a breadth of ideas which will be as much missed among his associates, as his characteristics of high personal integrity and invariable kindliness and helpfulness of disposition.

ALFRED NOBLE

There passed away on April 19, 1914, in New York City, Alfred Noble, an esteemed member of our council and a man whose loss will be deeply felt and deplored not only by the engineering profession of which he was one of the most distinguished members, but by everyone who had the good fortune to know him.

He had a very interesting career, and the story of his life, if adequately written, would be typical of that of many of the great men and builders of this nation.

He was born August 7, 1844, at Livonia, Wayne County, Michigan, where his parents resided on a farm. His early education was received in the district school of his native place, and during his spare time he worked on the farm.

In 1862, when only 18 years of age, he enlisted in the Civil War in the 26th Michigan Volunteer Infantry. From that time until 1865 he served in the Army of the Potomac, taking part in all of the hard and desperately fought battles which that army engaged in against Lee and Stonewall Jackson. At Gettysburg his regiment lost a very large percentage of its numbers. At Chancellorsville, it was by the merest accident that his brigade was not captured by Stonewall Jackson's men, but he was lucky in serving through the war without being wounded, and was mustered out of the service in June 1865 with the rank of sergeant. He then prepared to enter the University of Michigan, and in 1867 became a sophomore, graduating in 1870, with the degree of C. E. He received the degree of LL.D. from his alma mater in 1895, also from the University of Wisconsin in 1904.

From 1868 to 1870 he was assistant engineer on river and harbor work on the Great Lakes. From 1870 to 1872 he was in charge of improvements on St. Mary's Falls Canal and St. Mary's River. During this time the first great masonry lock at the Soult, then by far the largest canal lock in the world, was built. On completion of this work he became resident engineer on the construction of an important bridge at Shreveport, La., over the Red River.

From 1883 to 1886 he was general assistant engineer on the Northern Pacific Railroad, and from 1886 to 1887 resident engineer on the construction of the Washington Bridge over the Harlem River, at that time the largest arch bridge in existence.

From 1887 to 1894 he was resident engineer on the construction of several very large and important bridges over the Mississippi at Memphis and Alton, over the Missouri at Bellefontaine and Leavenworth, over the Ohio at Cairo.

He was appointed a member of the Nicaragua Canal Board by President Cleveland in 1895. This board visited Central America and examined the route of the Nicaragua Canal and also the Panama Canal and then returned to the United States, completing its work November 1, 1895.

In June 1899 he was appointed by President McKinley a member of the Isthmian Canal Commission which was charged with the selection of the best canal route across the American isthmus, and it has been substantially on the route selected by this commission that the Panama Canal has been constructed. While on this commission, Mr. Noble with his colleagues visited Europe to examine the existing canals there, and the data which the French Canal Company had in Paris, and also made several trips to Central America to examine more fully the various canal routes.

In 1905 he was appointed by President Roosevelt a member of the International Board of Engineers to

recommend whether the Panama Canal should be constructed as a sea level or a lock canal. This board consisted of thirteen members, of whom five were nominated by foreign governors. Mr. Noble was one of the minority of five Americans who recommended the adoption of the lock plan. Their views were adopted by the Government and the canal has been built in accordance with their recommendations. In March 1907 he was one of the three appointed by President Roosevelt to visit the Panama Canal to investigate the conditions regarding the foundations of some of the principal structures. This duty was completed in a few weeks. He was obliged to decline a similar appointment two years later.

From the very inception of the plan by this country to build an Isthmian Canal, and from the commencement of the preliminary investigations and surveys, to the adoption of the final plan and the beginning of the actual construction of the Panama Canal, Mr. Noble was continuously identified with the project and deserves as much credit for the solution of the engineering problems as any other one who has been connected with this great work.

In July 1897, he was appointed by President McKinley, a member of the United States Board of Engineers on Deep Water Ways, which made surveys and estimates of cost for a ship canal from the Great Lakes to deep water in the Hudson River.

In November 1901, the city authorities of Galveston, Texas, appointed Alfred Noble along with Henry C. Ripley and General Robert, as a board of engineers to devise a plan for protecting the city and suburbs from future inundation. They recommended the building of a solid concrete wall over three miles long and seventeen feet in height above mean low water, the raising of the city grade, and the making of an embankment adjacent to the wall; the whole to cost about three and a half million dollars, which plan has since been carried into effect.

From 1902 to 1909 Mr. Noble was chief engineer of the East River Division of the New York extension of the Pennsylvania Railroad, and was in entire charge of this most difficult piece of work, involving as it did, a very accurate survey across Manhattan, and the construction of the foundations of the Pennsylvania Station, of the land tunnels, and of the East River tunnels which were very troublesome.

Since 1909 he has been engaged in general practice as a consulting engineer, the firm name being Noble and Woodard. Probably the most important work dealt with was in relation to the dry docks built for the United States Government near Honolulu. He was also for a time consulting engineer to the Quebec Bridge Board, also consulting engineer for the Board of Water Supply, New York City, and for the Public Service Commission of the First District of the State of New York.

He was a past-president of the Western Society of Engineers, the American Society of Civil Engineers, and the American Institute of Consulting Engineers. He was elected to the Council of this Society in 1912 and had served several years on the Library Committee.

In 1910 he was awarded the John Fritz Medal for notable achievements as a civil engineer, and in the same year was elected an honorary member of the Institution of Civil Engineers of Great Britain, a distinction which no other American has had. In 1912 he received the Elliott-Cresson Medal of the Franklin Institute in recognition of his distinguished achievements in the field of civil engineering.

Mr. Noble was deeply interested in anything effecting the status of the engineering profession. His unfailing good humor, his kindliness and sweetness of disposition, his sound common sense and good judgment, his youthful mentality, his quick and very sure perception, and his modesty, invariably impressed his colleagues with whom he worked on many committees, and commissions in which he was so active.

He possessed a combination of strength, gentleness, tact and discernment rarely met with. He was universally respected by all who had any business dealings with him. The plain workman, the man with the pick and shovel, the contractor under him, the highly trained technical engineer, or the president of a great corporation, all appreciated the nobility, simplicity, and rugged honesty of his character. His personality was such as to evoke the faithful and enthusiastic loyalty of his subordinates, and the deep, strong, and lasting affection of all those who were honored with his friendship.

At the funeral services on the evening of April 21, the Society was represented by Jesse M. Smith, Past-President and member of the Council; Leonard Waldo, Chairman, and E. G. Spilsbury of the Library Committee, Charles Whiting Baker, Rudolph Hering, J. Waldo Smith, C. M. Wales, W. L. Saunders, and Calvin W. Rice, Secretary. E. W. S.

EDWARD PUCHTA

Edward Puchta was born October 15, 1870, in Washington, Mo., and received his education in the public schools and at Washington University, from which he was graduated with the degree of M.E. in 1892. In 1894 he entered the service of the Western Electric Company in Chicago as draftsman. From 1897 to 1899 he was employed by the Diesel Motor Company of America, as assistant engineer, under the supervision of Col. E. D. Meier, spending the first four months of his time abroad supervising the construction of engines being made for them in Germany.

In 1899 he returned to the Western Electric Company as chief draftsman, becoming in 1901 assistant superintendent of the Chicago shops. He held this

position until 1913, when he was appointed assistant superintendent in charge of the employment and welfare work for the Hawthorne works of that company, continuing in this work until the time of his death on February 25, 1914.

MEETINGS

CINCINNATI MEETING, APRIL 14

The members of the Cincinnati Section were the guests of the University of Cincinnati Student Branch on the evening of April 14, in the auditorium of the University. K. C. Grant gave an illustrated lecture on the Flood Prevention Work in the Great Miami Valley, a subject of considerable local interest. The flood of March 1913 caused great loss of life and property, and the dam and reservoir systems now under consideration for the prevention of future floods were explained in detail to an interested audience.

BOSTON MEETING, APRIL 8

At the meeting held in the Assembly Hall of the Engineers Club, Boston, April 8, W. O. Hildreth of the Lamson Company gave an illustrated paper on Selective Types of Conveyors. These are conveyors adapted for delivering packages or other materials from a central station, or from intermediate stations, to various other stations as selected by the sender at the time the goods are despatched. This paper and illustrations showed the practice in department stores, postoffices and industrial plants.

F. B. Williams of the same company presented a paper on Pneumatic Conveyors and illustrated particularly the tube systems for transporting mail, for long distances underground. The government specification requires a speed of 30 miles per hour for this service. He also showed numerous illustrations showing the cash systems in department stores.

S. L. Haines of the Link-Belt Company showed some slides illustrating the latest developments in the line, especially belt conveyors in use for handling large quantities of magazines and weeklies. He also showed several types of link-belt elevators for packages.

The meeting was well attended; a general discussion of the papers followed their presentation.

MEETINGS IN BUFFALO

H. M. Wilson, engineer in charge of the U. S. Bureau of Mines Experimental Station, gave an address at the meeting of the engineers of Buffalo, N. Y., on March 26, 1914, at which about 100 were present. Mr. Wilson chose as his subject, Mine Safety and Mine Rescue Work, and gave many interesting facts regarding dust and gas explosions. The lecture was illustrated by lantern slides and moving pictures.

On April 10, Prof. L. P. Breckenridge of Yale University lectured before the engineers on Industrial Germany, giving the impressions gained by him on his several visits. The workman of Germany, he said, is industrious, thrifty, patient, thorough, contented. In the last ten years no country has grown so fast industrially, and America is being forced more and more to meet German competition. Trade schools are widespread so that labor is trained. The German is apt to lack organization and direction in his industrial efforts, however, and for this reason more than 150 American managers have been taken to Germany to direct the industries.

MILWAUKEE MEETING, FEBRUARY 3

At a meeting of the Society in Milwaukee on February 3, Percy C. Day gave a talk on Wuest Herringbone Gears, giving an abstract of his paper on the same subject published in the Transactions, Volume 33. Lantern slides were used to illustrate his remarks.

NEW YORK, APRIL 14

At the monthly meeting of the Society in New York for April, Willard C. Brinton delivered an address on the subject of Graphic Statistics for the Engineer and the Executive. In his talk, which was illustrated with lantern slides, he described some of the graphic methods not generally used by engineers, but which could be of very great assistance to men who must frequently condense and abstract information and write reports. He showed that some of the comparative methods and graphical records now in use by the biologist and statistician could be quite generally applied to the work of the engineer if more widely understood. Most of the speaker's talk was a discussion of methods for keeping corporation operating records in convenient form for instantaneous reference by executive officers. This phase of the subject attracted a great deal of interest and some interesting discussion followed.

SYMPOSIUM ON WELDING AT BOSTON

At the March meeting of the Society at Boston a symposium was held on Welding topics, the four papers presented representing the processes of welding most generally used in industrial work, namely: welding with oil fuel, oxy-acetylene welding, thermit welding and electric welding. The speakers were as follows: W. N. Best, oil furnace specialist, of New York; Henry Cave, president of the Cave Welding Company, Springfield, Mass.; W. R. Hulbert, sales manager, Goldschmidt Thermit Company, New York; and W. A. Hodges, treasurer, Thomson Electric Welding Company, Lynn, Mass. The papers presented appear in abstract form below:

THE WELDING OF METALS WITH LIQUID FUEL

By W. N. Best, New York

Member of the Society

The oil burner should be able to thoroughly atomize any gravity of liquid fuel procurable in the open market, such as crude oil, fuel oil or tar. It is now well known that very heavy low gravity crude oil must be used, for this is the cheapest fuel, because it contains so little gasolene or other volatile matter that it does not pay to refine it. This oil at present is procured largely from Mexico, where the supply appears to be practically unlimited, but when the Panama Canal is completed, a great deal of heavy California crude oil of from 14 to 16 gravity Baumé will be delivered to the manufacturing interests along the Atlantic coast. While it is necessary to heat heavy oil to reduce its viscosity, this is a very simple matter.

The burner should be of such construction that it will not carbonize, and it should distribute a volume of flame and heat evenly throughout the entire charging space of the furnace without the use of brick or spatter walls. One of the secrets of success lies in having the furnace construction in every detail adapted to the work. In other words, to heat 8 in. or 9 in. of metal when a 3-in. heat is ample is very poor shop practice, for it means a loss of both time and fuel. Other vital points which must be considered are: the furnace construction should be such that the heat is evenly distributed and under the control of the operator at all times; the temperature of the metal should be uniform throughout the length and width of the sections to be welded; furthermore, the nature of the metal should not be changed while being welded, and the oxidization of the metal should be reduced to the minimum.

In welding safe ends on locomotive boiler flues, the usual practice when using soft coal as fuel, is to have one blacksmith and two helpers, it being the duty of one helper to bring the flue from the pile to the smith who heats it and of the second helper to rush it to the flue welding machine where it is welded. The average time required for thus safe-ending flues is 16 flues per hour, for the fire must be coked before a weld can be made, which means not only a loss of time, but also an irreparable loss in fuel for it requires both time and heat to liberate the gases from the coal. Modern practice is now to use an oil fired furnace of special design such as shown in Fig. 1, which insures a very short heat, approximately only 2½ in. long, and the heating of three flues at once. This furnace has a combustion chamber in which the atomized fuel unites with the air necessary for perfect combustion, which prevents

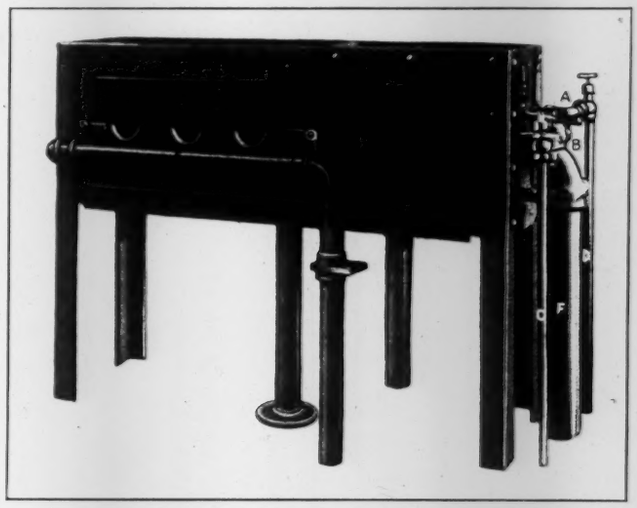

Fig. 1 An Oil-Fired Furnace for Welding Boiler Flues

oxidization of the metal while being heated, and as no sand or borax is required, 60 flues are welded per hour with exactly the same number of men as are used while welding 16 flues with a coal fire. The average welding machine is fully adequate to keep pace with such an oil fired furnace. Imperfect welds with this scientific method of operation are so few that it does not pay to give a water test to each flue, but when using coal as fuel this must always be done, for often the exterior of the weld will look perfect but it will be found to leak badly, because the sulphur in the coal corrodes the metal.

In welding scrap iron, a quantity of scrap is ordinarily piled upon a board, wired thereto and charged into a furnace such as is shown in Fig. 2. After being

heated in the usual manner, it is either hammered to size or rolled into billets in a breakdown mill. The use of oil as fuel for this class of work has the advantages that, first, a more even heat can be attained and maintained in the furnace than with any other fuel; second, the temperature of the heat or charge is uniform throughout; third, if a cobble gets on the roll of the breakdown mill which it will take some minutes to remove and to readjust the guide, simply by increasing the amount of oil flowing to the burner, the gases in the furnace can be changed from a dioxide to a monoxide which instantly stops the waste of metal, and then after the cobble has been removed, the charge can be made ready to draw in a moment's time by reducing the oil supply which again instantly changes the furnace gases back to carbon dioxide (CO_2); fourth, a greater output can be obtained from this type of furnace with oil than with any other fuel upon the market because the operator has the fire at all times under perfect control. In the majority of furnaces for this class of work the waste gases, in the same way as when burning coal, are passed through a boiler which is used for the generation of steam.

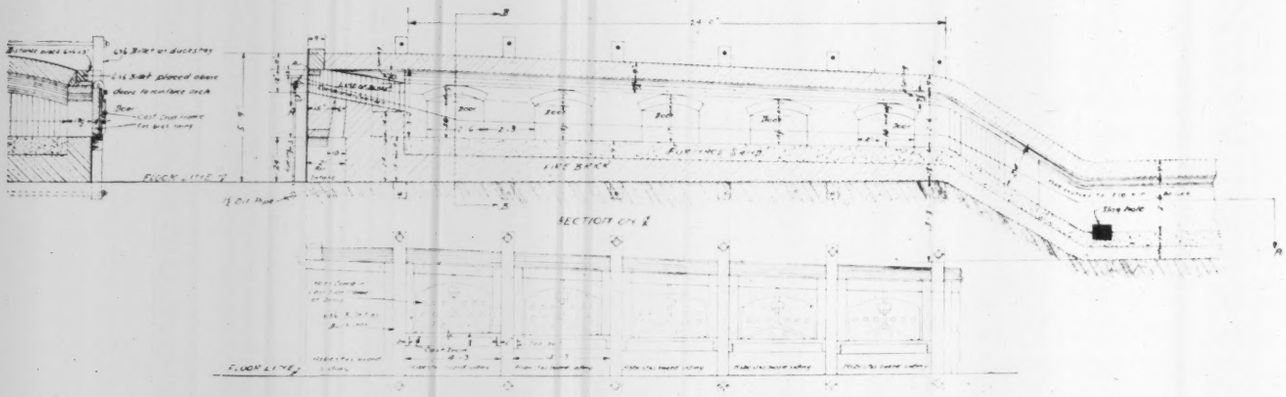

Fig. 2 An 8 Ft. by 24 Ft. Furnace, as used in Rolling Mills and Large Blacksmith Shops for Heating Scrap, fitted for Oil-Firing

Flange welding, such as the welding of flanges upon pipe, requires both skill and experience, and while oil is the ideal fuel as the heat can be evenly distributed without turning the pipe, the furnace construction is of vital importance. The furnace should be cylindrical in form, with a combustion chamber and burner so placed that the flame will enter the furnace tangentially, thus causing the flame and heat to encircle the flange and pipe (Fig. 3). The vents, through which the consumed and inert gases pass out of the furnace, must be so placed that they will not check the velocity of heat nor prevent the flange and pipe from being heated evenly in their circumference. This same furnace can also be used for "vanstoning" the ends of various sizes of pipe.

For forging purposes, oil is an excellent fuel, especially for large axles or shafts from scrap iron piles. The latter, after being heated, are hammered down into blooms say 5 in. by 20 in. by 5 ft. and ordinarily three blooms are used to forge an axle. Usually as many piles of blooms are charged into the furnace as there are doors. The piles are heated much more quickly with oil than with coal. It is a well-known fact that car or locomotive axles must be free from any defects such as seams or other flaws caused by imperfect welds, and as the use of oil as fuel means a 30 per cent reduction in the number of imperfect axles, it is of great benefit to both the employer and employee for it saves not only time and money but prevents wrecks.

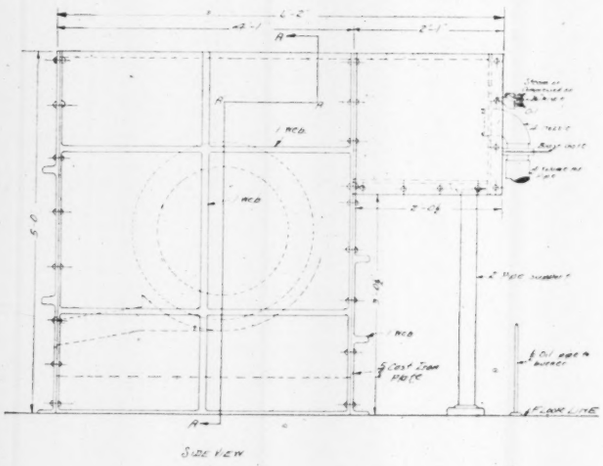

Fig. 3 A Pipe Welding Furnace used for Welding Flanges on Pipe, Operated with One Oil Burner

As before stated each class of work requires special oil equipment adapted to the size and kind of metal to be welded. For example, in welding wrought iron or soft steel to say 60 carbon steel, the construction of the furnace, as shown in Fig. 4, must be such that the flame will be delivered to the underside of the charge, thus deflecting the flame or abrasive heat upon the wrought iron rather than upon the carbon steel for the former requires the higher temperature. Of course in this case borax is used in making the weld and there should be a preheating chamber constructed in the fur-

nace so that the iron will be heated to 800 or 1000 deg. fahr. before the 60 carbon steel is laid thereon.

In the round house welding of broken locomotive frames (Figs. 5 and 6), the drivers are dropped in the usual manner, the break scarfed and an insert or "Dutchman" driven therein, after which a temporary furnace is constructed around the frame and a portable furnace then used to bring the frame up to welding heat. The blacksmith's work of welding the insert into the break can then be completed in a very few minutes. The time required for bringing the frame up to the welding temperature is approximately 40 minutes, and the quantity of oil varies from 2¼ gal. to 2½ gal.

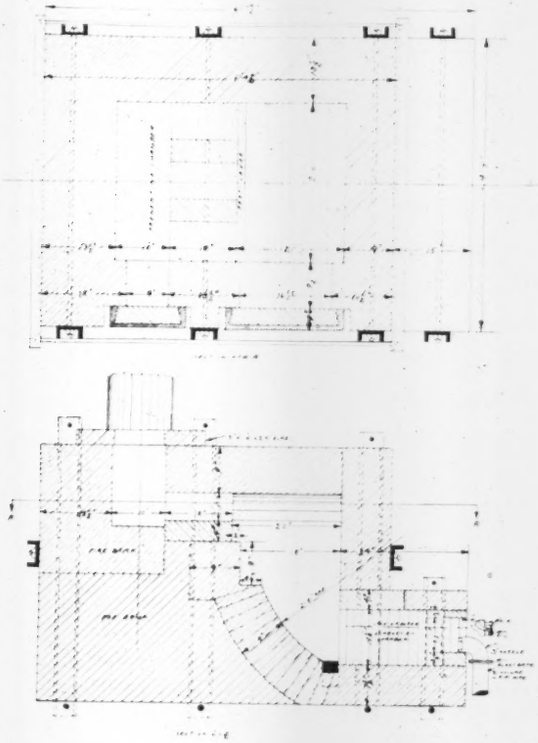

Fig. 4 Details of Special Oil Fired Furnace for Welding Wrought Iron and Soft Steel to 60 Carbon Steel

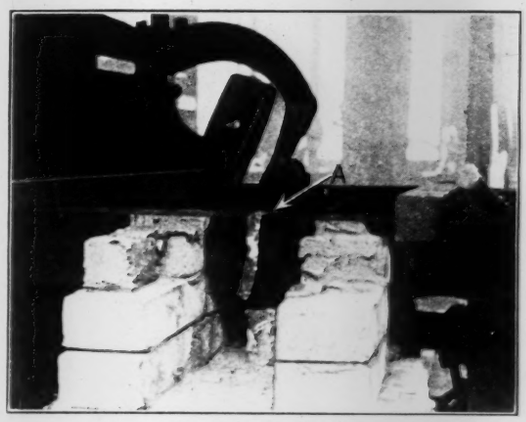

Fig. 5 Preparing Broken Locomotive Frame for Welding, showing Insert at A

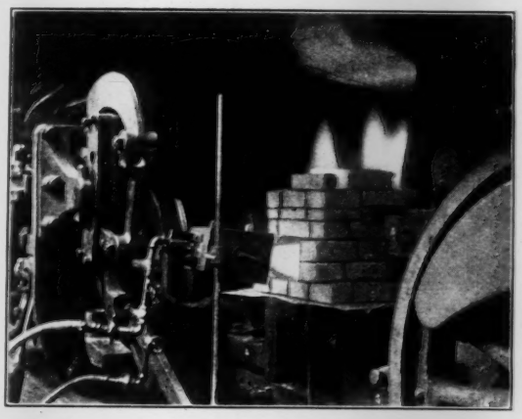

Fig. 6 View of Temporary Furnace in Place and Portable Oil-Burner in Action

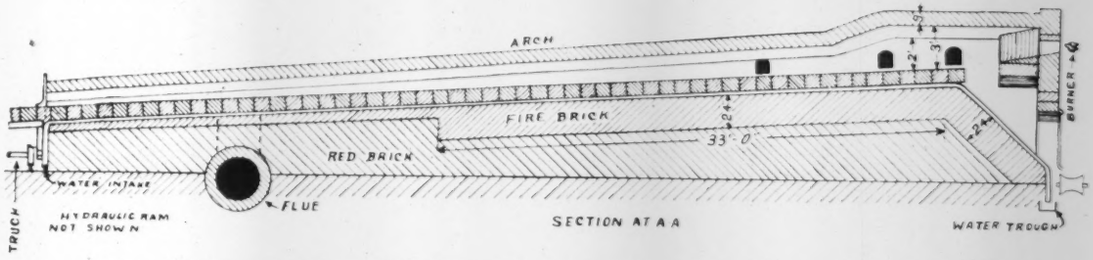

Fig. 7 A Continuous Type of Billet Furnace, as used in Wire Mills, fitted for Oil Fuel

The continuous type of billet heating furnace, shown in Fig. 7, is often used in wire mills. They are about 10 ft. in width and 70 ft. in length. Usually two rows of billets are charged in the furnace and of course the size of the billets varies according to the size of the wire or iron to be rolled, some being as small as 6 in. sq. by 3 ft. long, while others are 12 in. sq. and 4 ft. long. The billets are charged at one end and when sufficiently heated, by means of hydraulic rams placed in the charging end of the furnace, are dropped from the burner end of the furnace on to conveyors at the will of the operator. Having a furnace of this type insures the billets being heated gradually at a minimum cost of fuel. Only one burner is used on this furnace and the temperature is readily controlled by the operator.

THE OXY-ACETYLENE PROCESS OF WELDING

By Henry Cave,[1] Springfield, Mass.

Non-Member

Autogenous welding is a general term given to welding when metal fuses. In the ordinary blacksmith's weld the metal does not fuse; it becomes plastic and is hammered together, but unless hammered no weld would be produced.

Autogenous welding is carried out in several different ways, but as here referred to is by means of acetylene burned with oxygen. The use of oxygen with other combustible gases consisting of an oil gas similar to Pintsch gas termed "liquid" or "Blau gas" in this country, hydrogen and a few others are sometimes used, but are not efficient owing to limitations of temperature. The process using acetylene necessarily makes very much the hottest flame, owing to the large amount of carbon in the composition of this gas.

This process is an indirect development of electricity. Shortly after the electric furnace was developed, the general use of acetylene was made possible, calcium carbide, from which acetylene is generated, being made in the electric furnace. In 1895, shortly after the development of calcium carbide, Le Chatelier, the French scientist, proposed this process, that is, that the burning of acetylene with pure oxygen would produce a very high temperature. It was not, however, until 1905 that an equipment came into this country for practical use in a factory. From that time there has been a gradual development in the equipment and a rapid development in the uses for the process.

The acetylene is produced in a generator direct from calcium carbide, the gas passing through a reducing valve and hose that connects with the torch. If a welding equipment is to be used for portable work or work of an intermittent nature, acetylene is obtained from a dissolved acetylene cylinder as a source of supply, instead of from a generator, the other parts of the equipment being the same. The dissolved cylinders are not merely empty cylinders into which the gas is compressed as is the case with the oxygen cylinders, but contain a porous material, generally asbestos, into which is poured acetone or a similar liquid; the acetone absorbs the gas and the liquid is held in suspension, thus filling the cylinder at all times, and in that way it is perfectly safe under a high pressure. The gas is drawn off through a hose, as is also the oxygen from the other tank, and both are brought together in the torch.

The source of the oxygen in a general way is a cylinder of compressed gas. In some cases the compression is very high, up to 1800 lb. per sq. in., which high compression is for the sake of economical conditions of transportation. But in some cases it is used in low pressure cylinders (300 lb. per sq. in.) which are charged from generating equipment on the premises, or it may be generated and compressed directly into the service pipes by several different means. The chemical method of manufacture from chlorate of potash and manganese dioxide requires the cheapest equipment, but provides the most expensive gas, and is very little in use now. The electrolytic method of disassociating water into oxygen and hydrogen is coming very rapidly into use for large and small installations. Very large oxygen generating equipments have been installed throughout the larger cities of the country for making oxygen from the atmosphere by the liquid air process, the oxygen being distilled off from the liquid air.

The torches used in both welding and cutting work are provided with tips for producing different sizes of flames in each torch. That is the same as chang-

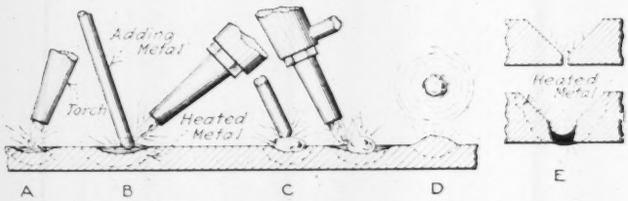

Fig. 1 Diagram showing Method of Making Typical Oxy-Acetylene Weld

ing the size of flame in a gaslight by removing a burner and replacing it with a larger or smaller one, the variation of flame being required for welding different weights of material. The tip is made of brass, there being one hole through the center, the mixing arrangement where the oxygen and acetylene are mixed together in correct proportions being located at the inner end.

In addition to the use of this process for welding, another operation of interest because of its connection with the oxy-acetylene process and that it is carried out with practically the same equipment, is the cutting of steel by means of oxygen. Cast iron and non-ferrous metals cannot be cut by oxygen, steel, wrought iron and cast steel being the only metals cut in this manner. I have known of considerable expense being undergone in attempts to cut cast iron, due to ignorance of this feature, the reason being, the free carbon in the iron stops the penetration of the oxygen. The cutting torch differs from those used for welding in that the tips have more than one hole; the central hole supplies the pure oxygen for cutting and the two outside holes are heating flames, identical with those used for welding.

The process of cutting steel in this way is a development of the old school experiment of inserting the red-hot end of a clock spring into a jar of oxygen, in which

[1] President, Cave Welding Company.

the red hot part of the clock spring began to glow and was gradually consumed, proving that steel would burn in an atmosphere of oxygen. The process is simply reversed in practice, in that the flame is applied to the piece of metal and a small spot heated, then the jet of oxygen is directed on that red-hot spot and the metal begins to burn; in burning it produces a slag of high temperature which, in flowing down the face of the part, is sufficient to heat the metal through a considerable depth (24 in. has been cut) so that the oxygen can combine with it. Thus the action is progressive, one layer being consumed heats the next one. It is not possible, however, to extinguish the heating flame as it is required to keep the molten slag fluid so that it will flow out of the cut; that is the only reason for keeping the combustion of the acetylene going while the cut is in progress after the first start is made.

This process of welding is not generally understood. There is a knack in making a strong weld, a knack that can be acquired only by the exercise of considerable judgment and practice. Fig. 1 shows the method of making a typical weld. The torch tip here carries a flame of 6300 deg. playing on the metal, and a pool of molten metal is first of all formed at *A*. The metal is heated up approximately as indicated by the shaded portion. Upon that spot is deposited a drop of molten metal from the rod of adding metal *B*, the end being fused into the melted pool *C*. The drop is then fused still further so as thoroughly to adhere it to the piece to which it is being welded, by playing the flame around that drop, until it assumes a shape as at *D*. With a sharp corner such as at *C*, no satisfactory weld would be produced, because there would be a spot on each side which could not be welded, but by playing the flame around a thorough weld right across would be obtained. The condition is very similar to the use of soft solder. Those familiar with it never trust work where the edges of the solder are rounded, but realize when they spread out to a thin edge the union is satisfactory. A succession of drops is put on in that way. These drops overlap each other, so a thoroughly strong weld is produced.

At *E*, Fig. 1, is a condition where parts are to be welded of considerable thickness. It should be stated that owing to the high temperature of the oxy-acetylene flame, a weld can be made from $\frac{1}{8}$ to $\frac{3}{16}$ in. in thickness without preparing the parts, that is, without beveling them out as shown at *E*. If it is a crack in a casting, it is chipped or ground out by means of some mechanical method, or if it is steel, it can be cut out by means of the oxygen jet and a groove formed. If it is attempted to make the weld from the outside without this groove, the metal would burn before its conductivity had time to convey the heat deep enough to make a weld of any depth.

With this process, the metal is first of all heated to red over a considerable area before any metal is added. The flame is then played at the bottom of the groove on the points of the prepared sections until they fuse together into one solid mass, and then additional metal is added. Thus the weld can be made completely through the parts. The additional metal is then built in and each drop fused to the side, producing a thoroughly homogeneous weld until the groove is filled up. This building up can be continued to any extent to reinforce the part at the weld or change its shape as desired.

The theory of the process of oxy-acetylene welding is shown in Fig. 2. A Davis-Bournonville high-pressure positive-mixture torch tip is shown at *A*. The acetylene, C_2H_2 passes in at the side orifices indicated and is ignited. When it is lighted in air a reaction takes place as shown (two and one-half parts of oxygen uniting with one part of acetylene yield carbon

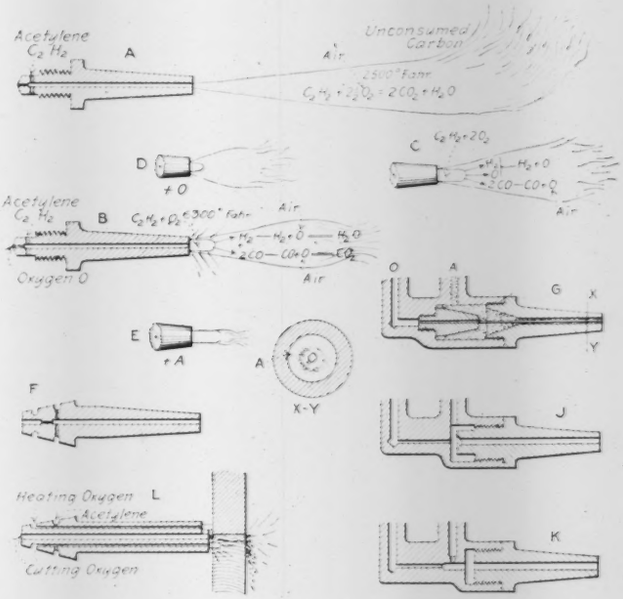

FIG. 2 DIAGRAM EXPLAINING THEORY OF THE PROCESS OF OXY-ACETYLENE WELDING

dioxide and water) and the reaction produces a temperature about the same as ordinary illuminating gas (about 2500 deg. fahr). The oxygen in this case is taken from the air; the fact that the air is only one-fifth oxygen is responsible for the fact that the gas has to spread out over a very large area to collect that one-fifth of oxygen, and also there is the four-fifths of nitrogen which is carrying the heat away needlessly. This heat is wasted and thus reduces the temperature of the flame. When the flame is burning, you will see that a considerable amount of unconsumed carbon is given off at the end of the flame, which shows that even then there is not sufficient oxygen for complete combustion.

When oxygen is supplied, from the cylinder or other source of supply of pure gas, passing in under pres-

sure at the small opening indicated at the end of the tip and striking the acetylene which is also under pressure, at right angles, a thoroughly homogeneous mixture is produced, and when a mixture of one part of oxygen and one of acetylene is provided by the size of the orifices, the reaction is as shown at *B*. (One part of oxygen uniting with one part of acetylene yields hydrogen and carbon monoxide.)

The high temperature of 6300 deg. fahr. is obtained in the bright cone immediately at the end of the tip. The hydrogen cannot burn in that high temperature zone as it cannot unite with the oxygen, because it is above the disassociation temperature of water. It therefore passes out to the long flame, which is called "the envelope," and burns to H_2O; neither can the carbon monoxide, the product of the first reaction, unite with the additional oxygen to produce carbon dioxide in the high temperature zone, and therefore this reaction must also take place in the envelope. The additional amount of oxygen is in both cases obtained

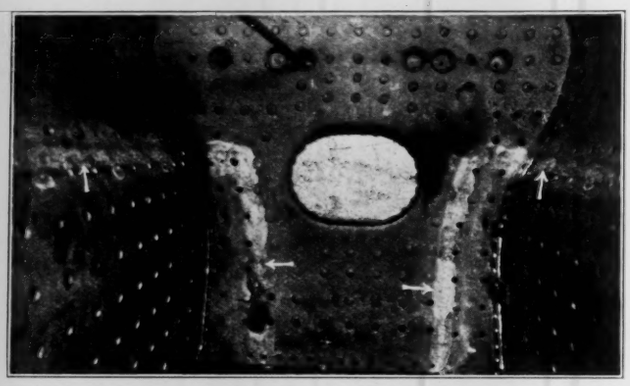

FIG. 3 VIEW OF SIDE PLATES WELDED IN PLACE IN FIRE-BOX OF A LOCOMOTIVE

directly from the air if a satisfactory design of torch is used.

The carbureting arrangement in the torch which is generally at the base of the tip, corresponds to the carburetor of an automobile, and if it is not adequate or not of a good type, the mixture and reaction will not take place as given above. If too large a proportion of oxygen is supplied, this additional oxygen cannot possibly unite with a combustible element in the high temperature zone of this reaction because all the carbon is used up by one part of oxygen. Therefore the surplus must pass through to the envelope, and as shown at *C*, we have the reaction indicated (two parts of oxygen uniting with one part of acetylene yield hydrogen, carbon monoxide and a surplus of free oxygen).

Part of the surplus oxygen going to the envelope unites with either the hydrogen or the carbon monoxide and forms carbon dioxide or water vapor in the secondary reactions, so that a portion only of the oxygen required for these reactions is taken from the air instead of all of it; some of it is, in other words, taken from the source of supply, at a cost of 3½ cents per cu. ft. (more or less, depending on conditions) instead of obtaining it from the air without cost, and that is obviously a very uneconomical condition.

If the means for bringing the oxygen and acetylene together are not such as will produce a vortex, and therefore cause all the molecules of oxygen to come in contact with the molecules of carbon in the acetylene, a certain proportion of the oxygen will pass out of the tip, and through the high temperature cone, unconsumed. Therefore to allow for this, a larger amount of oxygen must be supplied to obtain the normal adjustment of the flame which is distinguished by the clear outline of the inner cone. It can therefore be seen that this clear outline does not necessarily mean that the flame is neutral, as if the surplus oxygen is present as above, the flame must necessarily be oxydizing. The normal or ocular adjustment, as it might be called, therefore, may indicate a proportion of oxygen to acetylene of one to one (1.12 to 1 is the nearest to this that has been obtained) or it may indicate as high as two of oxygen to one of acetylene, 1.8 to 1 being very common.

If too large a proportion of oxygen is supplied through the tip for the normal setting as given above, the flame is shortened and the color is changed, *D*, as compared with *B*. The flame condition shown at *E* indicates too large a proportion of acetylene or a shortage of oxygen from the normal setting, the acetylene showing an extra or extended point on the bright welding flame. Those two extreme conditions are used by the operator to adjust his flame but he can only adjust it within the limits of the mixing device. This tip, *A* and *B*, is shown because it is a simple representation of the "high pressure positive-mixture" carbureting device, but has now been changed to the form shown at *F*, the principle of which, however, is the same. The tip seats in a cone and the oxygen passes through the central orifice and the acetylene through the radial orifices, striking together so that there is no question of a thoroughly molecular contact of the gases being produced before they pass out and are ignited.

Another type of torch which is shown diagrammatically at *G* is that in which the two gases are brought together by what is termed the injector principle, oxygen passing in and shooting straight through a chamber which contains acetylene either under several pounds pressure or under only a few ounces. The conditions are practically the same in both cases. The oxygen shoots through and the capillary attraction or "skin friction" of the oxygen draws in the acetylene and produces a condition in which there is pure oxygen in the center and pure acetylene around the outside, with the mixture in a zone between the two as shown in section *XY*. It is well known that the injector is made just as smooth as possible inside, so as not to produce any vortex; also that an automobile car-

buretor will not work satisfactorily unless the gases are thoroughly mixed together. The same applies to a torch. This torch is made in various styles. Sometimes the injector cone is a narrow passage and sometimes quite a large area; there are frequently jogs or enlargements in the passage with the idea of producing mixing effects. All the gas, however, passes through the center of them.

Another type of tip is shown at *J*. This differs only in detail from the previous one described, the principle being that of the injector, though without any cone, there being no control of the proportion of the two gases that pass in by orifices, such as are shown at *A*, *B* and *F*, the size of the orifices in these tips being accurately determined for the various sizes of tips for the amount of gas required, thus insuring the correct proportion at all times.

At *K* is shown another type in which there are passages which regulate the amount of gases passing through, but these are in the head of the torch instead of the tip. Therefore when a larger or smaller tip is inserted, the mixing passage remains the same, so that only one of the set of tips for that torch has orifices correctly proportioned.

At *L* is a diagram representing the cutting operation. This torch tip has a central passage through which the jet of oxygen passes. It has a side passage which carries an ordinary heating flame, the cutting being in the direction of the arrow, so that flame heats the metal in advance. There is also a following flame which is just the same as that used for welding, merely for the effect of keeping the slag fluid so that it will run out of the weld.

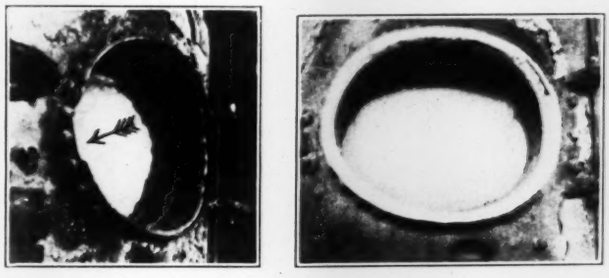

Fig. 4 An Example of a Corroded Firedoor Flange Built up with the Oxy-Acetylene Process

The process of oxy-acetylene welding and cutting is being used to a considerable extent for the repairing of steam boilers. In Fig. 3 is shown the welding of side plates in the firebox of a locomotive, the welds passing along each side and also patches being put in. It can be realized that having a row of rivets above the fire in a locomotive firebox is liable to cause trouble; by welding, this is entirely done away with. That weld has been in use on the Boston & Albany for three years, and proved perfectly satisfactory, as have others. In Fig. 4 is shown the building up of a corroded fire door flange. The corrosion is indicated by the arrow. In the ordinary way, it would be necessary to cut a large piece out and make a new flange and then put a row of rivets around both on the inside and the outside, and these rivets would have to be put in under very awkward conditions, owing to the small space, working through a hand hole, with the result that they might not be tight, whereas simply by building up as shown here, the work was made perfectly satisfactory.

There is, however, need of restrictions on boiler welding, because at the present time a welding equipment can be purchased at a very low figure, and unfortunately the concerns putting out the cheap equipments do not give instructions with their equipments, with the result that anyone purchasing an equipment can, without any knowledge of its operation, go ahead and carry out welding on a boiler. Sometime, and I guess it has already happened, destruction will result which will cause large restrictions in the use of this process. We are advocating that somebody, federal, state or other inspection authorities, make a law that no work shall be carried out on boilers unless the equipment has been tested to see that it will make a strong weld, and that it avoids the surplus oxygen which may pass through the flame oxidizing the metal and making a weak, brittle weld. The operator should be certified as to his ability to make a good, strong weld.

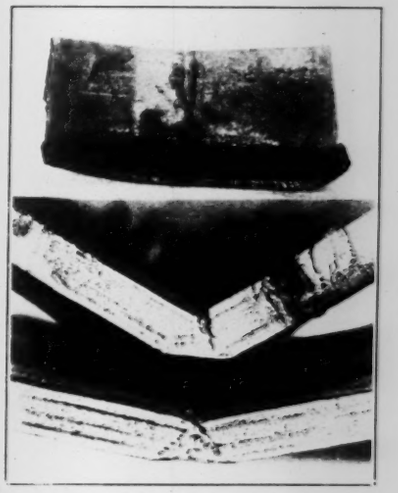

Fig. 5 Examples of Defective Welding by Improper Use of the Oxy-Acetylene Process

Even when these two conditions are perfectly obtained, success is not assured, because the operator is frequently merely an unskilled "handy man" who has been instructed in the knack of making a strong weld, but has no knowledge of boiler structures or the strength of metals or their heat treatment, and therefore is not capable of judging the conditions under

which welds should be made. We therefore claim that a third license should be given to the concerns that use the licensed operator and the licensed equipment, and until those three licenses are obtained welding should not be allowed on boilers. This does not imply that satisfactory work cannot be done on boilers at the present time, but as there are so many concerns who cannot do a satisfactory job of this sort, it is more by luck than good management when the right firm is chosen for the work.

Fig. 5 illustrates some of the possibilities of defective welding. Here is a weld that caused a disaster where there was considerable expense and loss. The weld is not thoroughly made. It was not made completely through and it is considerably oxidized. Regulations should be enforced so that it is not possible to get such a condition as that. Assuredly if the operators and concerns were licensed, they would not produce work of that nature. This process of welding is developing a number of other lines of metal working. For instance, pressed steel is coming into use very largely everywhere it is possible to use it, but its use has been limited to what could be made in dies. Pressed work in connection with welding has no limits, because the parts can be made in sections and then welded together. Fig. 6 shows the welding of such pressed parts, these plates being pressed up and welded together to make an expansion joint for steam piping. The parts are all welded together to make an accordion arrangement, the welding being around the inside and outside. It would not be possible to make that article without the oxy-acetylene welding process.

Fig. 6 An Example of Welding together of Pressed Steel Parts to Form af Expansion Joint

Cast iron can be welded perfectly satisfactorily. The metal will be soft if the work is carried out by a skilled operator with an equipment that does not remove the free carbon by combustion with the surplus oxygen in the flame, and it can be made so soft that expensive milling cutters and other tools can be used on it without any fear of their being damaged.

Fig. 7 shows a large flywheel, 20 ft. in diameter and weighing 24 tons, which was being moved from one mill to another and was dropped so that one spoke was broken out entirely and two spokes were cracked. It is easy to realize what an expense it would be to put in a new wheel, and also the time it would take. It was reported that the loss would have been $4800, but the wheel was welded up at a charge of $200 and put back into use. Thus a tremendous saving can be made, not only in the difference between the cost of welding and a new piece, but also the saving in time and use of the engine.

In making welds on a wheel of this size, it is not possible to turn it over and weld both sides, so the fractures were welded and reinforced by building up from the top side. There would naturally be some signs of the crack on the other side. It is well known when a piece of metal is nicked, it breaks very readily, and if a nick is left in the welding, it is much more liable to break than if it is welded up solid; so it was necessary to weld all around. The welding on the under side was carried out by the operator welding overhead. Cast iron, when it becomes liquid, is practically like water, and it was really a remarkable piece of work in welding up and building on that metal all the way round, part of it being done from underneath. The weld was tested with a sledge hammer to prove there was no internal strain in it. It was then run at calculated over speed, and I believe was reinsured by the insurance company that previously had carried the risk.

Fig. 7 An Unusual Case of Welding in Broken Spokes in a 20 Ft. Flywheel

Fig. 8 shows a weld in aluminum, which is an extremely difficult metal to weld, owing to several conditions. One is that it oxidizes so rapidly; another is that it has practically no strength when it is a few hundred degrees in temperature, being about as strong as a piece of potato. It has also high conductivity, so that a large portion of the piece is heated and the heat wasted. It has very high expansion and contraction. All these conditions make it an extremely difficult metal to handle; and yet it is possible to weld it as shown here.

What I believe to be the largest welding job that has ever been carried out and at the greatest saving, was carried out on the steel pipe line at Boulder Mountain in Colorado. The Colorado Power Company built this pipe line, using butt strap construction, which proved faulty. They tried all kinds of ways to correct the difficulty, but without avail. The trouble was that the water leaked out from between the butt straps, the water having a head of some 1700 ft., giving 825 lb. pressure at the base. The pipe was 4 ft. in diameter at the bottom and 1¾ in. thick. A tremendous amount of water came out from these joints and it was threatening to wash away the foundations and destroy the whole structure. Something had to be done immediately. Half a million dollars had been put into the structure and the whole thing was being held up. Finally it was welded by the oxy-acetylene process, in the winter on the side of the mountain, in a temporary structure which was moved from one point to another. A V-groove was first cut so as to make a deep weld, with the cutting torch. Part of the pipe ran through a tunnel, and joints were made at the mouth of one of the tunnels. The joints were all reinforced to 2½ in. thick, and gussets were also put in. The cost of that job, which was located some miles from any car line, was over $30,000, but it saved at least a quarter of a million dollars.

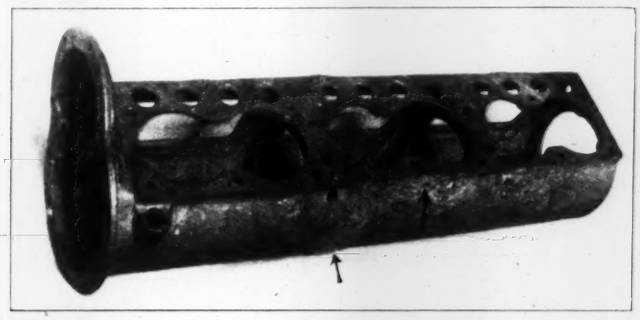

Fig. 8 An Example of Welding on an Aluminum Motor Crankcase

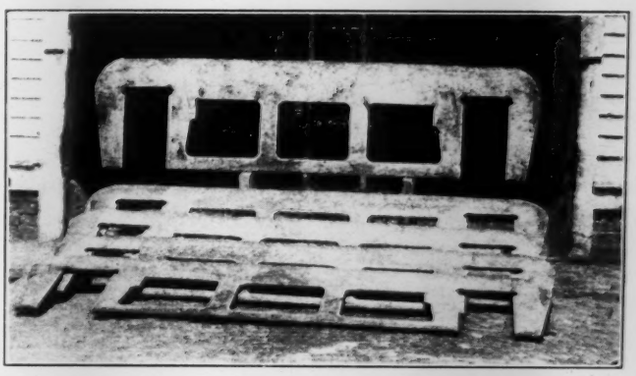

Fig. 9 A Motor Car Truck Side Frame Cut out of Steel Plate with the Cutting Machine

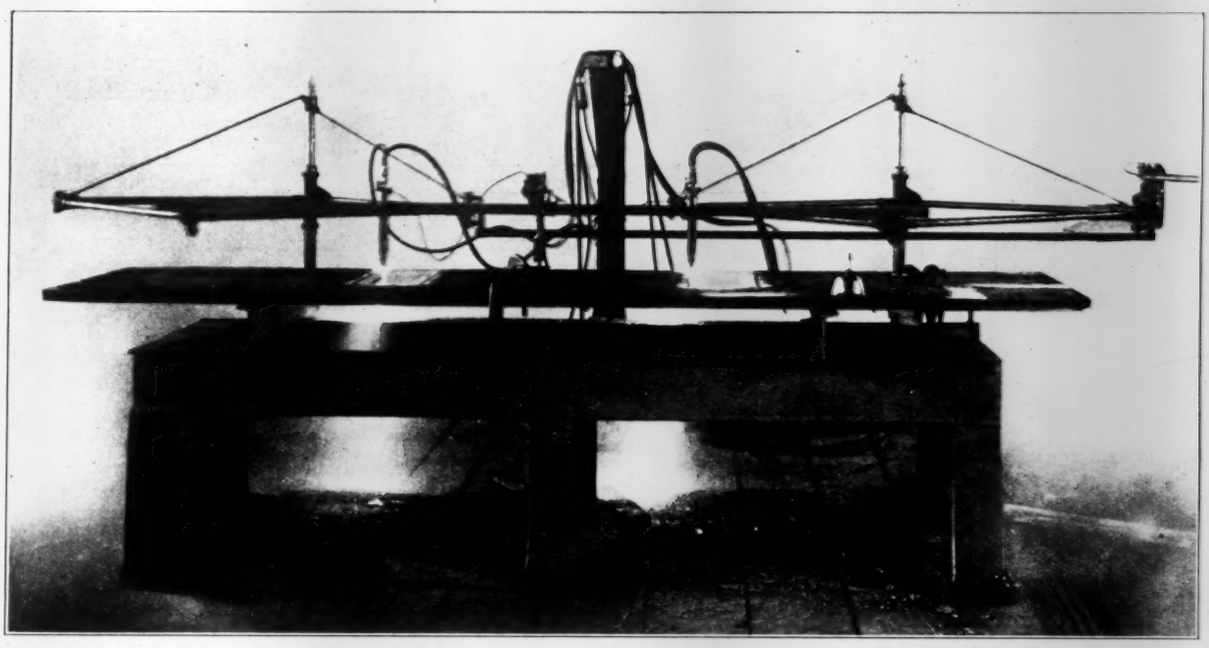

Fig. 10 View of the Oxy-Acetylene Cutting Machine in Operation with Two Torches forming a Steel Side Frame for an Electric Locomotive

In Figs. 9 and 10 is shown the method of cutting out frames for the trucks of motor cars. Previous to this process, the plates were cut by machine-shop methods, embracing first boring large holes, and then putting them on a planer and a shaper using parting tools. A row of holes is drilled for long curves, the metal broken off and an air chisel used to trim up. It took three days to get one out; whereas they are now cut out in 2 hours. They are ⅞ in. thick and about 12

feet in length, there being about 45 ft. of cutting. Each cut must be set separately, which takes most of the time.

The machine used for this work is shown in Fig. 10. It is a machine adapted for a variety of cutting operations of the kind usually handled on a vertical slotting machine or horizontal shaper, but it does the work much faster than a cutting tool. There is a substantial bed for holding heavy steel plates or forgings and an extension at the rear supports the pantagraph motion that guides the cutting torches. The double pantagraph frames are made of steel tubing and all joints provided with ball bearings. A horizontal bar is secured to the pantagraphs at the points opposite their pivots on the vertical supports. The tracing wheel which governs the movements of the torches is attached by a sliding block to any position on this bar according to the pattern or drawing to be followed and the required position of the torches. One or more torches are attached to the bar by similar sliding blocks. The illustration shows the tracing wheel at about the middle of the bar and a torch on each side making duplicate cuts. The tracing wheel is driven by a small electric motor which is provided with a centrifugal governor for regulating the speed at which the torches are moved thereby over the plate or material to be cut.

A full size drawing of the cut that is to be made is placed under the tracing wheel. The tracing wheel then follows the outline on the drawing and causes the torch or torches to follow a similar path over the work. The most irregular outlines can be easily followed. The speed at which the machine cuts is from 3 to 12 in. per minute, according to the thickness of the work. The torches used are the regular two-hose machine cutting torches manufactured by the Davis-Bournonville Co., vertical adjustment of the torches being obtained by means of a pinion operated by a thumb-screw which meshes with a rack cut in the body of the torch. The entire pantagraph motion can also be adjusted vertically by means of a handwheel at each end of the machine, which operates pinions meshing with rack teeth cut in the vertical supports. Any further adjustment that is necessary is then obtained by regulating the height of the torches with the thumbwheels. The latter adjustment permits, on certain classes of work where the thickness varies, of adjusting the height of the torch while cutting.

With this machine a cut may be made at any point over a surface 42 by 84 in. in size without shifting the torch on the bar. By shifting the torch or by using two torches, the area over which a cut can be made is increased to 42 by 168 in. Where duplicate work is being done or where two similar cuts are to be made in a single piece, the output of the machine is greatly increased by using two torches simultaneously. An example of this kind is shown in the accompanying illustration, Fig. 10, where a steel side frame for an electric locomotive is being cut.

THE THERMIT PROCESS OF WELDING

By W. R. Hulbert, New York

Member of the Society

Aluminum, which is the basis of the Thermit process, is the most widely distributed metallic element in the earth's crust, but it is an expensive metal as compared to iron and other more common metals because wherever it is found, it is always in combination with oxygen in one form or another, and it is only within comparatively recent years that any commercial process has been perfected which will separate aluminum from oxygen and enable the metal to be produced at a cost to make it generally available.

The fact that aluminum is hard to separate from oxygen is taken advantage of in the Thermit reaction as the high affinity of aluminum for oxygen permits of a chemical reaction between the two when they are heated hot enough. For many years since aluminum was discovered, chemists have known of this reaction and experimented with it in the reduction of different oxides, mixing finely divided aluminum with a metallic oxide, placing the mass in a crucible and then heating it until the reaction took place. It was found that this resulted in a very violent reaction, practically an explosion, so that the reaction was of no commercial value. Dr. Hans Goldschmidt, a German chemist and metallurgist, discovered that this reaction could be controlled, if instead of heating the entire mass, he simply heated the mass in the crucible at one spot. The reaction would then spread through the rest of the mixture and at the end of the reaction he would have aluminum oxide or slag floating on top in a molten state and the reduced metal at the bottom of the containing vessel.

This discovery was the result of experiments by Dr. Goldschmidt, who was attempting to produce for Krupps, the steel makers in Germany, pure metals to use as alloys with steel, and the first experiments were made with chromium oxide and finely divided aluminum. This reaction was entirely successful, as aluminum combined with the oxygen in the chromium oxide and pure chromium metal was reduced. He later experimented with other oxides, sulphides and chlorides and succeeded in producing pure manganese, ferro-chromium, molybdenum, ferro-titanium and many other metals and alloys.

In experimenting with iron oxide, it was found that this reaction not only produced a very pure, low carbon steel, but that the heat of this reaction was extremely high. No pyrometer will measure this temperature, but it has been worked out theoretically by Professor Richards of Lehigh University as approximately 4881 deg. fahr. Dr. Goldschmidt decided that this intense heat, produced so quickly and easily, could be used for welding purposes, and the Thermit welding process which is now widely known throughout the world is the result.

In making a Thermit weld, the parts to be united are first arranged with a space between them varying from ½ in. to 2 or 3 in., depending upon the size of the sections. In the case of a fracture, it is often necessary to cut out the metal in order to provide the space needed, and this is done by drilling a line of holes along the fracture and then cutting out the metal between the holes or else the space is cut out by means of the oxy-acetylene cutting flame. In the case of welding locomotive frames, which is the most important application of the process, it is almost always necessary to cut out the fracture.

After the sections have been cut out, a wax pattern is formed around them to the exact shape of the reinforcement of Thermit steel which is to be cast around them to make the weld. The wax pattern is enclosed in a sand mold, wooden patterns being used to form a pouring gate, also a small preheating opening at the bottom and a large riser directly over the top of the weld. In order to remove the pattern it is only necessary to apply the flame of a compressed air gasolene preheater into the preheating opening and the wax is melted out, leaving the mold ready for pouring. For that part of the mold which comes in contact with the Thermit steel a mixture of one-third fire clay, one-third ground firebrick and one-third good sharp silica sand is used; this is mixed dry and then moistened just enough to tamp well. This is used only for the facing material and is backed up with a mixture of one-third fire clay and two-thirds sand. This mixture is recommended because it is highly refractory and the Thermit steel goes into the mold at such a high temperature that a very refractory facing is necessary. The mold is, of course, thoroughly vented in accordance with good foundry practice.

After the wax is melted out by the preheater, the heating is continued until the parts to be welded have been brought to a good red workable heat. In the meantime, the charge of Thermit is placed in a conical shaped crucible suspended over the pouring gate of the mold, and when the sections are red hot, the preheater is withdrawn, the preheater opening plugged up and the Thermit charge in the crucible ignited. In from 40 to 50 seconds the Thermit reaction is completed and the Thermit steel tapped from the bottom of the crucible into the mold where it flows around and between the sections to be welded together, uniting them into one solid mass. The slag (aluminum oxide) does not enter the mold, but overflows at the pouring gate so that it does not interfere with the welding operation.

The process is a simple one and the only outside power required to weld sections of any size is a small supply of compressed air for the operation of the preheater. The outfit is portable and in many cases sections of very large size are welded without removal from their position, and therefore at a great saving in time and expense over obtaining new parts. This is particularly advantageous in the case of broken locomotive frames. It saves taking the frame out of the engine, welding it in a forge and replacing it. Furthermore the process permits of fusing a collar or reinforcement of steel all around the welded part, thus increasing the cross-section at that point and making it stronger than it was originally.

In welding a locomotive frame it is necessary to jack the frame apart from ½ to $\frac{3}{16}$ in. before putting on the mold in order to allow for the contraction of the Thermit steel when the metal in the weld cools. Where one part of a double-bar frame is being welded this contraction is allowed for by heating up the other section so as to expand it the required amount and holding that heat until the metal in the weld has solidified, after which the heat can be taken off and then both

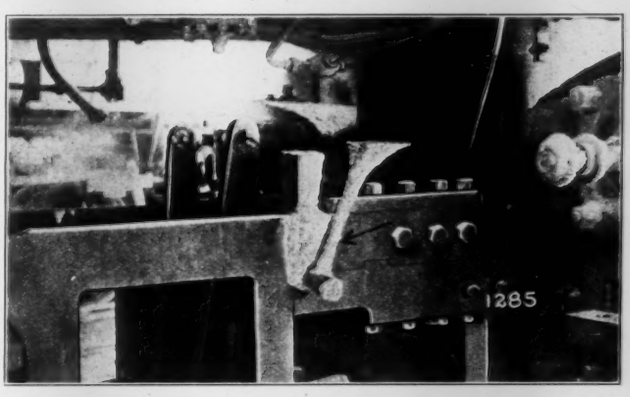

Fig. 1 A Completed Thermit Weld on a Locomotive Frame, showing Pouring Gate and Riser

sections will cool down and contract together. For such work a double burner preheater is used; one burner to preheat the sections to be welded while the other is directed into a small brick furnace erected around the second member in order to obtain the desired amount of expansion. A completed weld on a locomotive frame is shown in Fig. 1 with the mold removed.

The great economy of the process in locomotive repair work has led to its adoption by practically all the railroads of consequence in the United States, Canada and Mexico, and it is interesting to know that the process is now used in 421 different railroad shops in North America. Very little stripping of the engine is required for a Thermit weld, as it is necessary to provide only a clearance of about 1 ft. all around the broken section. In fact it is usually only necessary to drop the driving wheels in order to effect a repair on a broken frame. Often the engine comes into the shop in the morning and 12 hours later the frame will be welded and the locomotive ready for service. Thermit is also applied to equal advantage in the welding

of broken driving wheel spokes, side rods, connecting rods, rocker shafts, cross head guides, cylinder saddles, mud rings and other broken sections too numerous to mention.

The Thermit process is used extensively in the marine field for welding broken stern posts, stern frames, rudder frames and propeller struts of steamships. Here the process results in even greater economies than in the case of locomotive repairs owing to the fact that drydockage is exceedingly costly and every day saved means hundreds of dollars. Such repairs seldom keep the vessel in drydock more than 48 hours. The United States Navy has used the process very extensively at

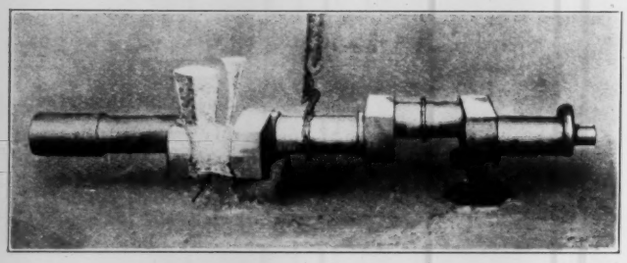

Fig. 2 A Completed Thermit Weld on a Large Refrigerating Machine Crankshaft

the Boston, New York, Norfolk, Portsmouth and Charleston navy yards, and the repair ships Panther, Dixie and Vestal are completely equipped with Thermit welding outfits and have done very important work.

A great many crankshafts have been welded by this process, particularly shafts for refrigerating machines. These shafts have to be aligned quite accurately before making the weld, and it is found best to mount them on *V*-blocks supported on a machined bed plate. In some cases it is found necessary to cut out an entire bearing and weld in a block of steel to replace it with two Thermit welds, one at each end, the shaft being then placed in a lathe and the bearing turned down to the proper size. It is usually impossible to keep these shafts in exact alignment during the welding operation, but they are seldom out more than $\frac{1}{32}$ in. This is readily corrected by taking a light cut off the bearings between the weld and one end of the shaft, considering the other part of the shaft to be true. In Figs. 2 and 3, an example is shown of a Thermit weld on a large crank shaft.

While a great many of these shafts have been welded with Thermit, we have never had one break at the weld, and our theory is that the shafts almost always break because of some flaw or defect in the material. This is often an old forging crack in the case of built up crankshafts, which gradually spreads until finally the shaft gives way. Of course, a shaft with such a flaw has no factor of safety at all, but if it were properly constructed it should have a factor of safety of five. After the weld is made and all surplus metal machined off the shaft will still have a factor of safety of at least four, which is ample for all purposes and the owner will really have a better shaft than originally because the flaw has been located and eliminated and the rest of the shaft has, of course, been thoroughly tested.

This process has also been used for large welds on gear wheels, flywheels, hoisting engine shafts, rolls, pinions and roll mill housings. In the case of broken rolls and pinions, it is usually necessary to cast on entire new ends and as this would prove rather costly with Thermit steel, we have devised a method which is just as effective and considerably less expensive. This method is now generally used by practically all the large steel mills in the Pittsburgh district. The broken roll or pinion is placed vertically in a pit and a mold constructed around the fractured end. This end is then heated to a red heat by means of gasolene preheaters, after which it is covered with Thermit steel to bring it up to a fusing temperature. Liquid steel from a ladle is then poured into the mold and about 6000 lb. allowed to run through and overflow. The overflow gate is then plugged up and the mold filled to the top. When the metal in the mold cools it will be found to have welded perfectly to the steel of

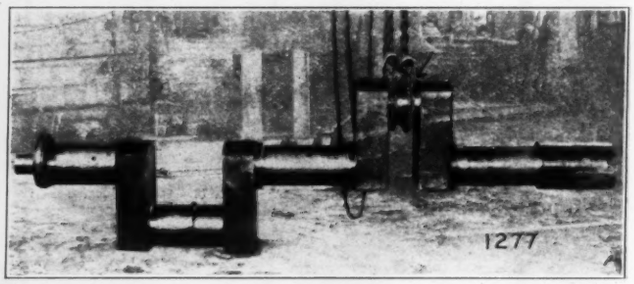

Fig. 3 View of the same Crankshaft after Welded Crank pin was Machined

the roll. The hot metal passing through the overflow gate is not wasted, but is caught in ingot molds and used in the regular way.

Another important application of Thermit is in pipe welding. The method of doing this work is novel and simple. Advantage is taken of the temperature of the slag and the fact that this slag will not stick to the pipe. On this account the mold for the purpose can be made of iron and surrounds the pipe ends which are accurately butted together and held in place with clamps. The Thermit is ignited in a flat bottom crucible and at the end of the reaction the slag which floats on top of the Thermit steel is poured into the mold, the steel going in afterwards. The slag and steel combined serve to bring the pipe ends up to a welding temperature, at which time they are squeezed together by means of the clamps and a butt-weld effected. At

the end of the operation the entire mass may be knocked away from the pipe and the only resulting effect will be a slight upset in the surface of the metal at the joint.

This type of welded joint is used extensively in refrigerating plants, particularly where ammonia pipe lines are used and where a permanent non-leakable joint is desired. The Thermit process not only eliminates all joints from the pipe, but the welded joints are actually cheaper to install than ammonia flanged connections. For instance, the cost, including labor, of welding a 1-in. standard pipe by the Thermit process, is about 65 cents, while ammonia fittings will cost at least 75 cents. Another advantage is the speed with which the welds can be made, as two men can easily make from 40 to 50 pipe welds per day. One man will face up the ends of the pipe with a special pipe facing machine, while the other follows and does the welding. As no outside power is required the welds can be made anywhere and the operation is just as economical in the field as in the shop.

In rail welding, the Thermit process offers a field of usefulness to street railway companies, as the apparatus is simple and enables a few joints to be welded almost as cheaply as a large number. The life of the rail depends very greatly on the efficiency of the joint as it always wears out and batters where the joints occur. Welding not only prolongs the life of the rail but also reduces the resistance of the return electric circuit. In making a rail weld, Thermit steel is fused around the base and flange of the rail and also around both sides of the head. The head is, however, not welded entirely with Thermit steel, but an insert of rail steel is placed between the two rail ends and this is heated to a welding heat by the Thermit steel and slag, and later when the weld begins to cool and contract, it is compressed between the rail heads and butt-welds to them. In this way a weld of the entire rail section is obtained, but one which does not in any way affect the wearing quality of the metal in the head of the rail which has to withstand traffic. After this joint has been welded it is ground to proper form by means of a special rail grinder which has been perfected for that purpose.

In addition to the above applications of the process it may be stated that Thermit is used quite extensively in foundries and steel works for reviving dull iron in the ladle and keeping risers of castings liquid. For that purpose the Thermit is supplied in cans which may be attached to a long rod and plunged into the ladle of iron or held in the riser. The Thermit there reacts and heats up the iron or steel in which it may be immersed. The reaction of the Thermit charge in the molten metal sets the iron free as highly superheated steel at a temperature of nearly 5000 deg. fahr., or about twice the temperature of ordinary molten steel, which is very effective for this purpose.

ELECTRIC WELDING

By W. A. Hodges,[1] Lynn, Mass.

Non-Member

The electric resistance process of welding and heating, sometimes called the incandescent process as distinguished from the electric arc process, consists in causing a heavy current of electricity to pass across the joint at the lowest voltage which will drive the current through the pieces to be welded, to bring the metal at the junction up to a welding heat, and at the same time pressing the pieces together to make a complete union or weld. The pieces to be welded together when clamped in a welding machine complete an electrical circuit but are inadequate to carry the heavy current passing through them without heating; as the heat increases the resistance also increases and the union or weld is thereby accelerated, but the volume of current is decreased, or in other words, as the temperature increases, the current volume usually decreases, a greater volume of current being used at the beginning than at the end of the heat effect. The heat is confined to the metal between the jaws and a welding heat is reached so quickly that there is very little time for waste through radiation or conduction by adjacent cold metal; therefore practically all the heat is consumed in useful work, and the pieces not having been heated except at the joint, are not distorted or even discolored.

The electric resistance process of welding and heating is distinguished from all other processes by the fact that the heat is generated in the metal itself, uniformly over the section, while by all other processes the contrary is true; the heat is applied to the exterior and is conducted into the interior. Absolute control of the heat is obtained; the pieces are heating in full view of the operator and, if, due to uneven contact of the pieces, rust or scale at one or more points of contact or other irregularity, the pieces heat unevenly with a tendency to burn at one or more points, the heating effect can be instantly stopped until radiation restores the heat equilibrium, when the heating can instantly be resumed and all danger of flaws avoided. Various degrees of temperature can be obtained and retained for any length of time. Usually no flux is required.

This process is employed principally in the following classes of welding operations:

- Butt Welding, end to end; whole abutting surfaces, of nearly same cross-section, welded together
- Tee and Angle Welding, in the form of a letter T or L
- Cross Welding, in the form of an X
- Lap Welding, overlapping and squeezing or mashing together
- Seam Welding, either by abutting, or overlapping, the edges of sheet metal

[1] Treasurer, Thomson Electric Welding Co.

Spot Welding, instead of riveting; practically one spot at a time

Point Welding, surfaces in contact only at a raised point or multiplicity of points, at which the current is confined; welding only at these points. Usually in sheet metal

Ridge Welding, instead of a point, a ridge, across which a weld is made

Upsetting, to form collars and the like, and

Heating, of blanks for forging, bending and working.

The process is especially well adapted to duplicate work where as large an output as possible per operator is required and the wagon, carriage, automobile and bicycle industries, with tools, wire, pipe, tubing and a large line of miscellaneous and special work provide the field for the process. It is particularly applicable to new work rather than to repairs, although some repair work is done in iron and steel, but the process is not applicable for the repair of broken or defective castings unless of such metals as brass of simple forms. Practically all metals can be welded, also all sorts of steel and many alloys, as well as many combinations like carbon steel to mild steel, nickel and brass to platinum, cast steel to machine steel, malleable iron to steel and a great variety of other combinations. In the last few years there has been a great development in the manufacture of sheet metal articles and the electric spot weld has been found a much cheaper and better method than riveting, especially with the lighter gages of sheet.

Rust is an insulator for low voltage and should be removed at those parts of the pieces which come in contact with the electrodes. In butt welding the two pieces, if of the same metal, should have practically the same cross-section at the joint, and when a larger piece is to be welded to a smaller, the end of the larger piece should be reduced to the section of the smaller for a length depending on the section or diameter. The upsetting of the ends together to make a butt weld causes the joint to be enlarged, according to the character of the metal and the kind of weld required, by a burr, fin or swelling; if objectionable, this can be removed under a press or hammer while the metal is hot, or in thin flat stock, where there is not enough heat to work, the light fin can be ground off.

The electric current transformer, the clamping device and the pressure device are the three necessary elements in an electric welding machine. Although it is possible to give the transformer a different location from that of the two mechanical elements, it is rarely done, the commercial welding machine employing all three elements in the same structure. There are, of course, many special departures from this general form. The mechanical and electrical controls may be operated by hand, by foot, or may be automatic and operated by power. For small work like welding wire, spring pressure in forming the weld is usually employed, and clamping either by hand or by power; for metals like copper and brass a weight pressure is usually best; for rounds and like sections up to ¾ in. hand pressures are usually employed; in larger sections, hydraulic pressure or pressure obtained through self-contained oil jacks is used.

Electric welding machines are necessarily more or less special in the construction of their clamps and electrodes, no one machine being suitable for a great variety of sizes or forms of work, and some are entirely special and suitable only for the work for which they are built. Some are called semi-automatic, as when the operator's duty is only the putting in and taking out the pieces, while other machines are entirely automatic, clamping, exerting pressure for welding and controlling current.

Power machines for spot welding are being built with heating time adjustments and regulation so that the machines can be set for the right speed and the correct time of heating required for varying thicknesses and conditions of stock. They can be operated continuously or intermittently as necessary, so that the greatest amount of work which the operator can handle will be taken care of by the machine.

There is no process by which the heat can be delivered to metal so quickly as by the electric resistance method. In small wire a fraction of a second only is required for welding, while with larger pieces proportionately more time is required. Welds can be made either quickly or slowly, depending upon the amount of power available. It is always desirable to have ample power so as to make the weld in the quickest possible time, as better results are usually obtained, and time and power are saved. A ¾-in. round can be welded with 15 kw. in 15 seconds or with 23 kw. in 6 seconds. Endless pieces like rings take more power, as the diameter decreases; copper and brass, more power and less time than steel or iron of like section.

The expense for current is small, as it is used only while the pieces are heating in the welding machine, which is from one-quarter to perhaps one-half of the time of the day's run. The welding machine is always ready if the current is available by simply closing a switch, and when the weld is made the expense of consumption of energy instantly stops. The output per day for any welder depends, of course, upon the size of the stock to be welded, the shape of the pieces, and the facilities for handling. In wire hoops, under the best conditions, 1000 welds can be made per hour, while in very heavy tires, 100 per hour would be a very good output.

Large volumes of current at low pressures are required, approximately from 2000 to 50,000 amperes, at from 1 to 7 volts, being used for welding from ¼ in. to 3 in. round or equivalent section. The pieces to be welded when mounted on the terminals of the transformer, complete an electric circuit, all parts of which, except the pieces to be welded, are adequate to carry

this heavy current without heating excessively or without much loss of energy. The current depends on the section of the pieces and the speed of welding.

An alternating current wired from a single phase, or from one phase of a multi-phase system is the most convenient and is universally used. A current of any usual frequency can be employed, the welding transformer being adapted for the conditions, 60 cycles usually being found, although welding machines are employed on circuits of 25 cycles and even as low as 11½ and 15 cycles. The pressure also may be any commercial voltage, 220 volts being commonly available, although welding machines are operated on circuits ranging from 104 volts to 550 volts.

This current is usually obtained from the local lighting and power company rather than from individual generating plants, although in cases of large electric welding installations individual generator equipments are used. In installations of single welding machines, the current being used intermittently, the actual kilowatt-hours consumed in a day's run are small and the expense of current so light that an individual generator is not desirable.

The welder being a machine with self induction, the power factor is low, sometimes 50 per cent, varying according to conditions, but rarely higher than 70 per cent. The nature of the load on the generator supplying the current is different from that of almost any other current consumer except some forms of alternating-current motors on account of the fact that when the circuit is closed through the breakswitch, the full amount of power required to make the weld is instantly thrown on the generator; and instead of building up from a minimum to a maximum, the maximum is first demanded of the generator. This necessarily creates some disturbance on the line.

When the visible surface of a piece (outside) reaches a welding heat the interior is necessarily also at a welding heat; for this reason, a more uniform result and a greater percentage of good welds can be obtained, and at least as strong, if not a stronger weld can be made than by any other method.

No table of strength of welds is presented, but in general it may be said that in good open-hearth mild steel, almost, and in some cases, quite the strength of the metal section is obtained. Bessemer steel, being frequently higher in sulphur and phosphorus, cannot always be welded with such good results.

In high carbon steel the heat is so distinctly localized and its dissipation is so fast when the current is withdrawn, that just at either side of the weld the metal is chilled and may be more or less brittle. To overcome this, it is the practice to reclamp with the electrodes wider apart, letting the current flow through the brittle parts until they come to an annealing temperature. Reheating may be repeated when needed.

A spot weld frequently is much stronger than a rivet. In very thin sheets the metal pulls away leaving a hole in one sheet with the metal of the weld adhered to the other sheet.

Fig. 1 shows in the left upper corner a steel pinion and a composition base piece with a boss to which the pinion is welded. The welded piece is also shown with the upset, represented by a fin around the joint. The three middle pieces are interesting specimens, showing the possibility of simplifying forgings by making them in two parts and then welding them. The first two pieces represent the two parts and the third piece at the right the completed piece, showing the weld. At the right-hand corner is a miter joint in a 1 in. pipe. This is rather an unusual weld. The two lower pieces are interesting examples of building up a structure from different parts. The two end pieces are forgings,

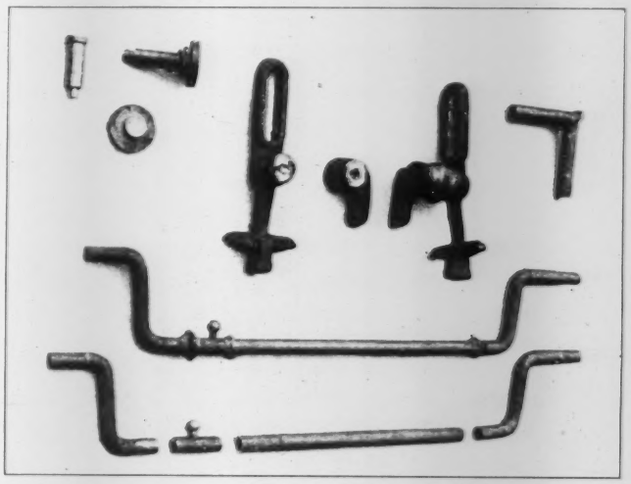

Fig. 1 Examples of Recent Applications of Electric Welding to Manufacturing Processes

also the small middle piece. The other middle piece is tubing. Three welds are made in the piece, which is shown welded above. The ends of the forgings to which the tubing is welded are milled out to give them a section like that of the tube.

There is an infinite variety of welding work which can be done by the electric resistance process, an interesting example of which is the welding of rails for the street railways, taking the direct current from the overhead trolley, transforming it to alternating current and welding plates across the joint, making a practically continuous rail. This work is being very extensively done in the large cities. An unusual method of making agricultural wheels consists in assembling the spokes in two halves of the hub and mashing them all together at one operation in a welding machine. There should also be mentioned the welding of wire fabric used in wire fencing and for concrete reinforcing, for which has been developed the only fully automatic electric welding machine; the strand wires and the stay wire are fed into the machine and welded automatically at all intersections.

MEETINGS OF THE SOCIETY IN CHICAGO

THE January and March meetings of the Society held in Chicago are of interest because of their bearing upon steam power plant topics: At the meeting of January 28, 1914, Bryant Bannister of Pittsburgh, Pa., read a paper on Tests of Four-Pass Boilers with Illinois Coal. On March 18, a banquet was held at which four prominent power plant engineers talked on the topic of Large Steam Power Plants, discussing the various phases of present-day operation and suggesting improvements for the future; the speakers were as follows: I. E. Moultrop, of the Edison Electric Illuminating Company, Boston, Mass.; J. W. Parker, of the Edison Illuminating Company, Detroit, Mich.; John Hunter, of the Union Electric Light & Power Company, St. Louis, Mo.; and W. L. Abbott, of the Commonwealth Edison Company, Chicago, Ill., all of whom are Members of the Society. The meetings and the discussion are reported herewith in abstract form.

TESTS OF FOUR-PASS BOILERS WITH ILLINOIS COAL

By Bryant Bannister,[1] Pittsburgh, Pa.
Non-Member

In April 1913 a new boiler house was completed at the works of the National Tube Company, at Kewanee, Ill. Because of some unique features of the installation, together with the fact that a low-grade Illinois coal was burned in the form of 1¼ in. screenings with very high efficiency, it was thought that the results of tests which were conducted would be of value to the engineering world.

A series of 11 tests of from 4 to 24 hours' duration, with loads varying from 75.6 per cent to 205.2 per cent of rating, was run primarily for the purpose of proving contract guarantees. However, with a Taylor stoker with which this plant was equipped, and its thick fuel bed, it is very difficult to estimate accurately the amount of either coal or ash on the grate, and the error which might occur in a test of short duration would be of considerable importance.

In order to eliminate, as far as possible, any error arising from this source, it was thought best to conduct a later test of much longer duration, so that any error in estimating coal on the grates at the beginning of the test would be spread over a sufficient period to make it comparatively insignificant. This test was run as a 72-hour test, completed October 30, 1913, some six months after the first 11 tests were made. The results of this 72-hour test are given in this abstract.

The complete boiler plant consists of four Edge Moor watertube boilers, each set as a unit, having 20-ft. tubes, and baffles arranged to give four passes for the gases, with the stack outlet at the bottom of the fourth pass. Each boiler has 6132 sq. ft. of water heating surface, Foster superheaters being installed. The boiler is set with the bottom of the front header 8.67 ft. above the level of the dumping plate of the stoker, thus giving the large combustion chamber so essential to the thorough combustion of highly volatile coals. The other furnace dimensions are 12.75 ft. wide by 8.50 ft. deep. The firing is done by a seven-retort Taylor stoker equipped with an air extension grate. Each stoker has its own fan and engine.

The feedwater is supplied from a purifying plant and is heated by the exhaust from the auxiliary engines in an open heater. Two turbine-driven centrifugal pumps, each having a capacity sufficient for the maximum steam generation, are so piped that any one of the four boilers may be supplied with feedwater by one pump, while the other pump supplies the water to the weighing tanks and to the remaining boiler units. Permanent water weighing equipment has been installed, consisting of two scale tanks of 2750 lb. capacity, and one supply tank of 4500 lb. capacity.

Much was done to make each boiler setting tight and as free from radiation losses as possible. The setting was first painted with a thick asbestos paint, and then covered with 1½ in. coating of 85 per cent magnesia heat insulator, and finally covered with muslin and again painted to insure no air leakage. The boiler headers were also covered, where exposed, with this same magnesia compound, and the whole setting top covered with a 3-in. layer of fire brick and cement, and then with magnesia covering. At no point during the tests was the setting more than warm, even at the highest loads.

During the tests the coal was dropped from a chute into a scale-box of 1000 lb. capacity and carefully weighed, then shovelled into the stoker hopper. From each weighing, a sample shovelful was taken and the aggregate of these kept in a tight metal box for each 8-hour run, and then quartered for a sample. Moisture determinations on coal were made by the National Tube Company, according to standard laboratory methods, and proximate analyses were made by both the National Tube Company and the Robert W. Hunt & Company from the samples obtained from the aggregate of the 8-hour samples. In test No. 12 it was found that the analysis made by the National Tube Company was

[1] Engineer, National Tube Company.

Abstract of Paper. Presented at the Chicago local meeting of The American Society of Mechanical Engineers on January 28, 1914. The complete report may be consulted in the rooms of the Society, 29 West 39th St., New York.

sustained by the heat balance and was accordingly used. (In test No. 12 the calorific value of 1 lb. of dry coal was found by the National Tube Company to be 11,094 B.t.u., and by the Robert W. Hunt and Company 11,026 B.t.u.) Ash analyses were made by the National Tube Company on samples from all tests obtained by the same method described above for obtaining coal samples, with checks by the Robert W. Hunt & Company on several tests. Care was taken in securing these samples of ash to obtain as nearly as possible the same proportions of fine ash and clinker as contained in the ashes dumped.

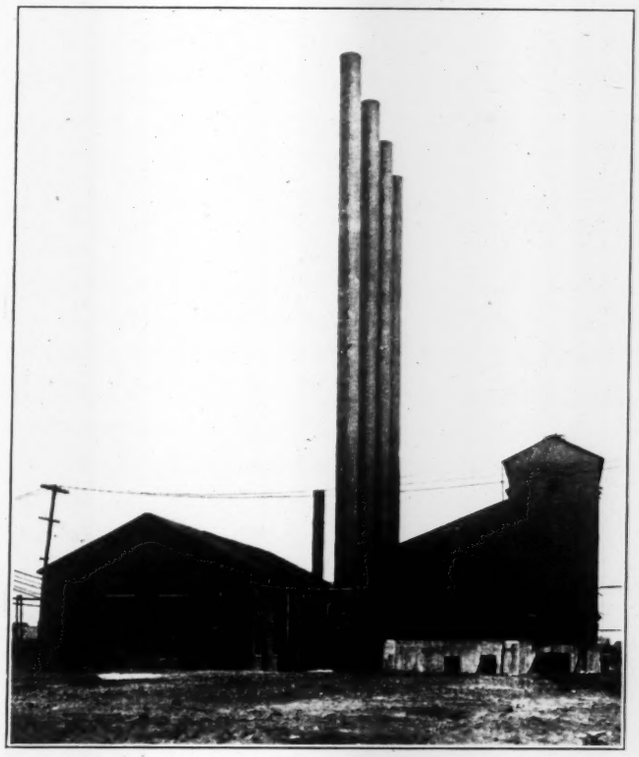

Fig. 1 Exterior of the New Boiler House at Kewanee

Flue gas temperatures were taken with duplicate thermo-couple pyrometers placed at the bottom of the last pass. Previous to tests these pyrometers were compared with a standard thermometer throughout the working range, and during the tests the average difference in the readings for the two instruments was about 6 deg. fahr.

Gland leakage on the test feed pump was weighed and accounted for, and no blowdowns were made during any tests. Safety valves on the test boiler were set several pounds above those on the remaining boiler units, but on the higher evaporations pop-offs were unavoidable, these being carefully timed and accounted for.

Flue gases were drawn from the bottom of the fourth pass and analyzed by an Orsat apparatus every 15 minutes, and check analyses were made occasionally with a second Orsat. All temperature and pressure readings were made every 15 minutes and the condition of the fire maintained in accordance with the gas analyses. Since each boiler unit has its own stack it was further possible to regulate properly the air supply to the stoker by observing the smoke condition. As shown by the data, the furnace draft was maintained as low as possible.

TABLE 1 DATA AND RESULTS OF EVAPORATIVE TEST NO. 12

Conducted by the National Tube Company, Kewanee Works, October 27-30, 1913, with Taylor Stoker of 91 Sq. Ft. Grate Surface, and Edge Moor Water-Tube, Four-Pass Boiler, of 6132 Sq. Ft. Water Heating Surface and 1200 Sq. Ft. Superheating Surface. Illinois Bituminous Screenings used.

Duration, hours	72
Average Pressures and Temperatures	
Steam pressure by gage, lb.	117.6
Temperature of feedwater entering boiler, deg.	194.9
Temperature of escaping gases leaving boiler, deg.	412.0
Draft in furnace, in.	0.011
Blast Pressure under Grate, in.	1.95
Superheat of steam, deg.	77.9
Total Quantities	
Weight of coal as fired, lb.	222,703
Moisture in coal, per cent	16.15
Total weight of dry coal consumed, lb.	186,736
Total ash and refuse, lb.	39,185
Ash and refuse in dry coal, per cent	20.98
Total weight of water fed to boiler, lb.	1,563,910
Total weight of water evaporated, corrected for moisture in steam, lb.	1,563,910
Total equivalent evaporation from and at 212 deg. fahr., lb.	1,727,964
Hourly Quantities and Rates	
Dry coal consumed per hour, lb.	2594
Dry coal consumed per sq. ft. of grate surface per hour, lb.	28.5
Water evaporated per hour, lb.	21,721
Equivalent evaporation per hour from and at 212 deg. fahr., lb.	24,000
Equivalent evaporation per hour from and at 212 deg. fahr. per sq. ft. of water heating surface, lb.	3.28
Capacity	
Evaporation per hour from and at 212 deg. fahr., lb.	24,000
Boiler horsepower developed	695.6
Rated capacity in evaporation from and at 212 deg. fahr., lb.	21,155
Rated boiler horsepower	613.2
Rated capacity developed, per cent	113.4
Economy Results	
Water fed per lb. of coal fired, lb.	7.022
Water evaporated per lb. of dry coal, lb.	8.375
Equivalent evaporation per lb. of dry coal, lb.	9.254
Equivalent evaporation per lb. of combustible burned	11.711
Efficiency	
Calorific value of 1 lb. of dry coal, calories	11,094
Calorific value of 1 lb. of combustible	13,773
Efficiency of boiler furnace and grate, per cent	80.95

TABLE 2 TEST AND COMPUTED RESULTS

Actual load, h.p.	696
Actual rating per cent	113
Engine speed, r.p.m.	225
Blast pressure, in. of water	1.95
Draft, in. of water	
Furnace	0.011
Fourth pass	0.255
Stack	0.90
Temperature flue gases, deg. fahr.	412
Superheat, deg. fahr.	77.9
Pressure gage, lb. per sq. in.	117.6
Feedwater temperature, deg. fahr.	194.9
Factor of evaporation	1.1049
Flue gases, per cent.	
CO_2	13.33
O_2	5.35
CO	0.08
Total	18.76
Coal	
Ash (dry), per cent	19.45
Hydrogen (dry), per cent	4.58
B.t.u. (dry)	11,094
Moisture, per cent	16.15
Carbon in dry ash and refuse, per cent	6.73
Equivalent evaporation per lb. of coal	
As fired, lb.	7.76
Dry, lb.	9.25
Equivalent evaporation per 10,000 B.t.u. fired	8.34
Equivalent evaporation per hr. per sq. ft.	
Grate surface, lb.	264
Heating surface, lb.	3.28
Coal per boiler horsepower-hour	
As fired, lb.	4.45
Dry, lb.	3.73
Coal consumed per hour per	
Sq. ft. grate surface, dry, lb.	28.5
Retort	
As fired, lb.	442
Dry, lb.	371
Lb. air per lb. dry coal fired	10.88
Efficiency boiler, furnace and grate, per cent	80.95

ANALYSIS OF FULTON COUNTY COAL

Proximate analysis of coal	
Moisture	16.15
Ash in dry coal	19.45
B.t.u. per lb. dry coal	11,094
Ultimate analysis of dry coal	
Carbon	59.15
Hydrogen	4.58
Sulphur	3.36
Ash	19.45

TABLE 3 HEAT BALANCE, EVAPORATIVE TEST NO. 12

	B.t.u.	Per cent	Per cent Correction
(95) Heat absorbed by boiler	8980	80.95	
Net correction to balance correction on items (96)–(102)			−0.79
Corrected efficiency		(80.16)	
(96) Loss due to evaporation of moisture in coal	231	2.08	
Same, calculated on average moisture in coal	(194)		
Correction to average moisture			−0.33
(97) Loss due to heat carried away by steam formed by burning of hydrogen	494	4.45	
Correction for items (96)–(97) on basis of corrected stack temperature			−0.03
(98) Loss due to heat carried away in dry flue gases	855	7.71	
Correction for item (98) on basis of corrected stack temperature			−0.21
(99) Loss due to carbon monoxide	35	0.31	
Same, average for all tests	(24)		
Correction to average carbon monoxide			−0.10
(100) Loss due to combustible in ash and refuse	223	2.01	
Same, average for all tests	(388)		
Correction to average loss of combustible in ash			1.49
(101)–(102) Loss due to radiation and unaccounted for	276	2.49	
Correction			−0.03
(103) Calorific Value of 1 lb. of dry coal	11094		
Total		100.00	0.00

NOTE—The above factors of correction were derived with items (indicated by numbers in brackets) of the complete code of the Society for boiler testing.

DISCUSSION

G. A. GOODENOUGH[1] commended the accuracy of the test instruments and measuring apparatus employed and stated that under the supervision of A. P. Kratz all instruments and apparatus were tested with special care and therefore the data set forth in the report of the test might be accepted as well within the limits of reasonable accuracy.

JOSEPH HARRINGTON (written). The heat balance has been worked out on a basis of dry coal, and the losses due to moisture and hydrogen in the coal and the heat in the dry flue gas have not been divided to show what proportion of each is a necessary loss. To this extent the analysis of the results is incomplete.

A perfect furnace would completely burn all the combustible in the coal fired, with just the theoretical amount of air. With no losses due to combustible in the ash, to CO in the furnace gases or to excess air, the furnace efficiency would be 100 per cent. A perfect boiler would cool the gases to the temperature corresponding to the pressure and would allow no infiltration of air or radiation of heat. The boiler efficiency would then be 100 per cent.

A perfect furnace and a perfect boiler would not, however, give 100 per cent combined efficiency, because nature imposes certain restrictions upon the process of burning coal for the generation of steam:

a Because coal is not a perfect fuel. With a perfect furnace and boiler the moisture and burned hydrogen in the coal will go up the chimney as superheated steam at the temperature to which a perfect boiler could cool the gases, but this temperature is higher than that of the atmosphere and a definite, necessary loss occurs.

b Because the gases must escape at a temperature at least equal to the steam temperature, which is, of course, always higher than the surrounding air. The theoretical amount of dry gases also carries away heat, which even a perfect boiler could not absorb.

The magnitude of these necessary losses depends upon the amount of moisture and hydrogen in the fuel, the boiler pressure, and the temperature of the air in the boiler room,

[1] Professor of Thermodynamics, University of Illinois, Urbana.

and until they are known and a proper allowance for their effect made, a test cannot be scientifically analyzed or two tests compared. For instance, a test of 78 per cent combined efficiency may be a better performance of both boiler and furnace than another at 80 per cent under different conditions, because the necessary losses might be more than enough to account for this difference.

After deducting the necessary losses per pound of coal as fired from the B.t.u. as fired, there remains an amount of heat, all of which a perfect boiler and furnace could utilize. The ratio of the amount of heat theoretically available to that contained in a pound of coal as fired is the ideal efficiency and should form the basis for all analyses of results.

The ratio of the amount of heat actually utilized to the amount theoretically available is the true measure of the boiler and furnace performance and is the only basis on which results can be scientifically analyzed. I term this ratio the "actual efficiency" of boiler and furnace.

The ideal efficiency for the Kewanee test is about 89 per cent. The combined efficiency of 80.95 per cent is, therefore, about 91 per cent of that theoretically possible and 91 per cent is, therefore, the real measure of the performance or actual efficiency of the unit.

Judgment of furnace and boiler performance on a basis of the total heat in a pound of coal is really an unfair proposition and I propose to remove all handicaps and put everyone back to scratch by basing furnace and boiler performance on the theoretical maximum. Advantages or disadvantages due to moisture and hydrogen in the coal, boiler pressure and atmospheric temperature are thus eliminated and a true comparison is expressed by the actual efficiency.

If further analysis of a test is desired, the furnace and boiler losses may be considered separately and the individual performance of each determined, but in any event, the performance should be based upon the heat theoretically available per pound of coal as fired, rather than upon the total heat in a pound of coal as fired.

The evidence is all in favor of accepting the actual efficiencies at Kewanee instead of those as corrected and this is directly in line with my own experience that at high rates of combustion the unaccounted-for loss increases rapidly, unless an unusually large furnace is provided. This often limits the range of efficient operation. The Kewanee tests differ from the Detroit tests in that at Kewanee the most efficient furnace capacity was exceeded at about 120 per cent of rating, whereas at Detroit the limit of efficient furnace capacity was not reached at 200 per cent. The most noticeable point of excellence at Detroit was the large combustion chamber, whereas at Kewanee it was the low flue gas temperature.

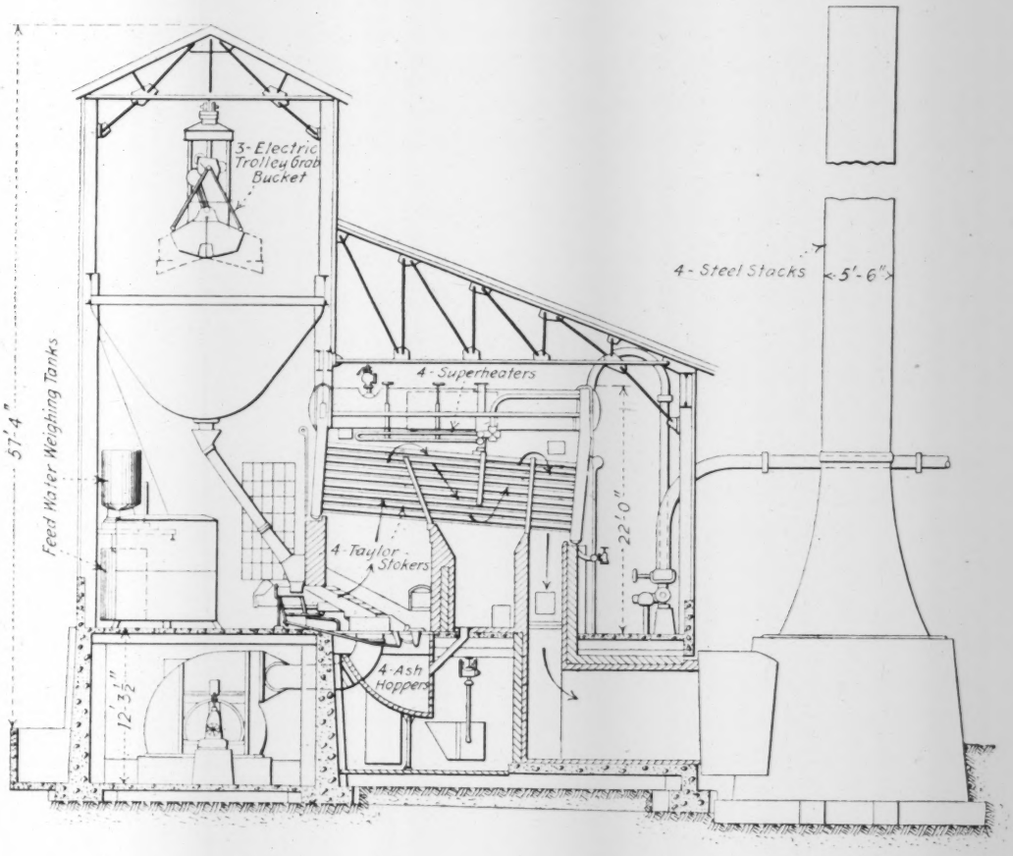

FIG. 2 CROSS SECTION OF THE KEWANEE BOILER HOUSE, SHOWING ARRANGEMENTS OF BOILERS AND AUXILIARIES

The question of unit efficiency, or rather range of unit efficiency, is of great importance on account of its bearing on station economy. If a whole station is to be operated economically, it is essential that the capacity-efficiency curve of a unit be known, and a series of carefully conducted and analyzed tests is necessary to establish this curve.

The amount of coal required to keep a boiler banked must then be accurately determined. With this information and the boiler room load curve before him, the engineer is able to establish a scientific schedule of operation.

The number of boilers in service should be such that each operates at or near its point of maximum efficiency, if the load on the entire station is practically constant, but as this is seldom the case, a certain range of unit capacity is necessary. When the point is reached where further decrease in unit capacity causes a decrease in efficiency which will more than offset the loss of banking one boiler over the period of low load, banking should begin. With increasing load, additional boilers should be put on as soon as the load becomes large enough to permit their efficient operation. This affords protection against an unexpected or early increase in load by keeping as many boilers as the line can operate efficiently and also has every boiler thoroughly warmed up and all fires in good condition before the peak load comes on. For short peaks it will usually be found most economical to drive boilers to their maximum capacity, even if this is above the limit of efficient operation.

After a schedule of operation has been developed, it is then necessary that each unit be operated as near to the test conditions as possible. The test conditions of draft, gas analysis, flue gas temperature and combustible in the refuse should be maintained as nearly as possible and this can be done only by keeping continuous and accurate records and immediately locating and rectifying any condition that is not right. Records of coal burned and water evaporated should also be kept and the cause of any decrease in the evaporation followed up and removed. It is only by such methods that continuous maintenance of most efficient conditions is secured and in view of the fact that many boiler rooms having up-to-date equipment operate at between 50 per cent and 60 per cent efficiency, the importance of such methods of operation cannot be denied.

A high efficiency test, like the one under discussion, does not guarantee low steam cost in yearly operation. The fight is only well begun. Of greater importance is the maintenance of those conditions that contributed to the high efficiency recorded. The apparatus here described could be so operated as to offset its inherent efficiency, so that the annual steam cost is really a factor, not only of the apparatus efficiency, but of the efficiency of the boiler room organization, which organization is extended to include the man paying the bills.

H. Boyd Brydon thought that there was little doubt that on the 72-hour test No. 12, a gross efficiency approximating closely 81 per cent was actually obtained; but, before this figure could be used for purposes of comparison, account had to be taken of certain items, of which no mention was made in the paper, which had to be charged against this efficiency. One was the steam consumption of the engines operating the stokers, fans, etc., used for burning the coal. He hoped that Mr. Bannister would be able to add to his paper information as to the steam consumption of this auxiliary equipment. Several approximate figures have been given from time to time as to the steam consumption of this type of stoker equipment, varying from 2 per cent to 4 per cent of the steam made by the boiler. In tests[1] of very large boilers at Detroit made by Dr. Jacobus, the steam used by the stoker and its auxiliaries varied from 2.61 per cent to 3.41 per cent in a series of seven tests, or an average of 2.78 per cent. It would seem that approximately this percentage should be deducted from the apparent efficiency of the combined apparatus, since the amount of steam thus used was not commercially available.

It was not an answer to state that the exhaust from these various auxiliaries could be put into a feedwater heater, and most of the heat thus recovered. We were not interested here in a plant test; we were interested in the results as a boiler test and the steam consumption for this apparatus was greatly in excess of that required for operating some other types of stokers, chain grates for example.

The results further appeared to be open to some correction in the matter of the amount of the radiation and miscellaneous losses. On checking the results with the Taylor stokers at Detroit against the figures here given, it was noticeable that radiation and miscellaneous losses at Detroit averaged about 3.3 per cent for tests at approximately the capacity obtained in test No. 12 (see Table 16, Dr. Jacobus' paper); for the Kewanee test, this item was given at 2.49 per cent. It was possible that radiation loss in the Kewanee tests was less than was the case in the Detroit tests, on account of the exceptionally careful manner in which the boiler setting was lagged. On the other hand, the relative furnace volume in the Kewanee tests was very much smaller than in the Detroit tests as pointed out by Mr. Harrington, which would inevitably materially increase the unaccounted-for loss aside from radiation.

Fig. 3 View of Interior of the Boiler Room

Another item which entered into the costs of obtaining the efficiency given, which should be deducted in order to obtain the net efficiency of the process, appeared to be the amount of steam used in the soot blower. The speaker wished to be informed as to the frequency with which these were used during the 72-hour test and the length of time the valves were open; and if possible, the approximate amount of steam used in keeping the boiler clean.

In explanation of the efficiency obtained advantage was

[1] Tests of Large Boilers at the Detroit Edison Company, D. S. Jacobus, Trans. Am. Soc. M. E., vol. 33, p. 565.

claimed for the low steam pressure employed. In test No. 12, the average steam pressure was 117.6 lb. gage, or the boiler water was approximately at a temperature of 349 deg. fahr. The low temperature of the water in the boiler naturally promoted efficiency by rendering possible a low flue gas temperature, but this could be used only as indicating the necessity for correction before the test could be compared with others, as most of the important power houses of the present day are operating at pressures greatly in excess of this. Assuming the same difference in temperature between saturated steam and flue gas, as in test No. 12, approximately 63 deg. fahr., the final flue gas temperature for boilers operating at 200 lb. would have been about 450 deg. fahr. The effect of this would be to increase several of the losses by an amount aggregating approximately 2 per cent.

While, therefore, the low steam pressure operated advantageously in this case, he thought that it could not be considered to be practically useful, as the value of the higher pressure in reducing steam consumption would very much more than offset the improvement in boiler efficiency.

If we apply the Detroit figure for radiation and miscellaneous losses and for steam consumption of the stoker equipment, and correct the results for increased steam pressure, it would appear that 81 per cent should be reduced to approximately 75½ per cent. Such an efficiency obtained with western coal was an interesting result and one which must have afforded the designer of this equipment great satisfaction. The figure possibly represented about 5 per cent higher efficiency than was accomplished in every-day practice in some of our large western power stations under similar conditions. It therefore became of particular interest to ascertain the cause of this improved economy, speaking of the test simply as a boiler test, not as a plant test.

Two things appeared responsible for the improvement shown. The principal item, it was believed, was the use of a four-pass setting; the second was the vary careful lagging of the boilers. It was to be regretted that further information was not presented in the paper that an estimate might be made of the importance of these items. Unquestionably the use of a four-pass boiler was an economical improvement.

From data at hand it would seem that considered as a gas cooler, the use of four passes might result in an improved economy of about 2 per cent, as compared with three passes. If this were true, there remained about 3 per cent improved economy, which presumably should be credited to the stoker. There was some doubt in the writer's mind as to whether this difference would in every-day operation actually show any material saving over the chain grate when the fixed and operating costs of the very much more expensive equipment were considered.

It was generally understood that in the case in point, important economies had been effected as compared with the results obtained in normal operation of the pre-existing boiler plant. This was entirely probable and would be expected with any modern boiler plant in comparison with an old plant. In the speaker's own experience, monthly operating figures in a somewhat similar case had shown that with a reconstructed boiler plant, double the load was carried for the same coal cost.

If Mr. Bannister would favor us with data on the cost of repairs on these stokers, also on the means taken to prevent the accumulation of clinker on the side walls of the furnace and on the ease or difficulty of cleaning the fires and removing ashes and clinker, the information would be of value and would enable comparison to be made with other types of furnaces burning similar coals.

R. H. Kuss (written). The paper prepared by Mr. Bannister deserves special consideration from the fact that it brings forward definite information respecting a combination of a boiler and furnace, previously untried in the Middle West where a coal of comparatively low native heat value is encountered. Considerable experience with the combination has been accumulated in the Eastern States with high-grade bituminous coal, so that the novel features encountered in this series of tests spring really from the kind of coal employed rather than from any other feature.

Even without correction or adjustment the efficiency results are exceedingly good. It is, however, profitable to analyze the results so that whatever benefits have come about may be properly distinguished and located. Certain critical items of the series of tests can be picked out to advantage. One of these is the low gas exit temperatures which argue a high percentage of heat absorption; or, in other words, high true boiler efficiency. This is particularly accounted for by the baffling.

During the 72-hour test, No. 12, temperature readings were taken regularly at points above and below the fourth pass. The averages of the calibrated readings showed a temperature difference of 67.4 deg. fahr. which indicates a heat absorption of a little above 2 per cent of the heat value of the fuel.

If it is conceded that the last pass is responsible for this amount of heat saving, there is still to be accounted for a very appreciable amount above that usually encountered with standard three-cross pass boilers. The conclusion is inevitable that the baffling of the first three passes contributes in no small degree to the general high efficiency results, or a temperature as low as 470 deg. fahr. would not have been encountered at the end of the third pass, even crediting the setting with special provisions against radiation and air leakage. It is clearly shown that for good absorption results, 18 ft. tubes are not necessary for three-cross pass boilers, provided the baffling is such as to employ the heating surface to advantage. I believe that one of the most important items of design is the selection, in this installation, of an inclined flame plate instead of the usual flame plate at right angles with the tubes. Fig. 1 of Mr. Polakov's paper on Task Setting for Firemen[1] can be studied to advantage in connection with the baffling employed at Kewanee.

It is obvious that the tube proportions could not have been duplicated without the inclined first flame plate, and this test series, combined with the close scrutiny of many other four-pass installations, causes us to conclude that it is not possible to create a successful four-pass setting with all of the baffling at right angles with the tubes, even when using 20 ft. tubes unless it is understood that the setting is to sacrifice a large part of its elasticity in capacity possibilities. If this conclusion is correct, then the next question to be determined is an adequate security against baffle leakage and general baffle deterioration. The use of tile resting against metal supports in an inclined position is not successful in the construction of the inclined flame plates. Recourse is best taken to building the first flame plate especially by the

[1] The Journal, Am. Soc. M. E., December, 1913, p. 1734.

older, more costly and perhaps less attractive method of "grouting" in position baffles made up of plastic refractory material reinforced with metal as was done in the installation at Kewanee. That this method made possible the location and protection of soot blower pipes is worthy of note, though the main reason for the selection of this construction came from a desire to create a tight baffle in an inclined position.

A study of the draft losses in the boiler as a whole permits interesting speculation, though it is unfortunate that no analysis of the draft throughout the setting was possible, owing to avoidance of soot dusting doors or special openings for that purpose. Based on observation taken in other installations, it may be stated with accuracy that the draft losses in a four-cross-pass setting for a boiler of a given size, using 20-ft. tubes suitably baffled, is no greater than for a three-cross-pass setting for a boiler of the same size. It is accounted for by the fact that in the three-cross-pass design, needless or useless draft losses are created before the gases enter the damper frame; in the vertical exit around drums, because the areas are placed at a disadvantage to the natural direction of gas travel and in the rear exit type, owing to the necessity of the gas passing through a great many rectangular openings between circulating tubes placed before the damper opening.

In order to apply the foregoing statement, it is well to note that the first flame plate must be in an inclined position with respect to the tubes and not at right angles with the tubes when dealing with the four-cross-pass arrangement. I wish to point out that the same draft intensity at the damper frame is not provided for the same chimney proportions, comparing the two types of installations, owing to the lower gas temperatures in a case of a four-pass boiler; therefore, to make possible the same draft intensity at the furnace or at the damper opening, the draft-creating facility should be increased for the four-pass scheme by an amount at least equal to the temperature difference equivalent in chimney height.

It is worth comparing the proportions of two installations of the same size, using the Kewanee design as one, and the more familiar three-cross-pass boiler setting of the same furnace width as the other. Such a three-cross boiler of approximately the same horsepower would have 312 four-inch tubes 18 ft. long; there would be two drums instead of three, lest the gas passages around the drums be too much restricted in area. It is, of course, possible to select a wider boiler not so many tubes high to obtain the same horsepower rating, in which case the areas around the drums would be larger but still not large enough to afford ample space for the use of three drums.

The ratios of the dimensions of two such boilers would be as follows:

	Kewanee Boilers	Typical Three-Pass Boiler
Heating surface, sq. ft.	6130	6200
Height of setting	19 ft. 10½ in.	20 ft. 9 in.
Width of setting	15 ft. 7 in.	15 ft. 7 in.
Length of setting	23 ft. 0 in.	21 ft. 0 in.
Contents of setting, cu. ft.	7130	6758
Contents water and steam space, cu. ft.	1064	929
Contents water space, cu. ft.	825	766
Contents steam space, cu. ft.	242	163
Steam disengaging surface, sq. ft.	192	127

These figures show little difference in the setting dimensions but a rather large difference in the cubical contents of the two types of installations. Where the water conditions are severe the importance of these proportions are quite manifest.

Aside from the greater economy in the absorption of heat due to four passes in place of three passes, several other important advantages are:

a The breeching is below the boiler; consequently the boiler room may be somewhat lower than for a three-cross-pass setting; the breeching is out of the way of piping; heated air surrounding the breeching due to radiation can be carried direct to the furnaces beneath the boiler room floor; the boiler room is cooler.

b The cleaning of soot from tubes more effectively done because the gas passages are less in width.

c Where the plant arrangement permits, the space between the normal boiler room floor and the rear boiler header can be used for breeching construction. Almost the entire setting behind the furnace bridgewall is of little use in the three-pass setting; the brick cost, air infiltration and radiation losses of these walls can be largely done away with by constructing the breeching immediately behind the furnace bridgewall. By the same design there is created a boiler room floor level behind and between the settings, from which soot blowing, washing, blowing-down, etc., can be accomplished without the use of platforms or ladders. The disadvantage of two elevations disappears if the engine room floor is of a higher elevation than the boiler room, and provided that the engine room is located behind the boiler room. The setting cost plus breeching cost is less than for a normal three-pass setting plus a breeching.

T. A. Marsh (written). The wide variation in the analysis of coal reported in the Detroit Edison tests[1] suggests the desirability of reporting the analysis obtained by the National Tube Company in comparison with those obtained by Robert W. Hunt & Company for each sample. No mention is made of the type of calorimeter used in either laboratory.

It is mentioned that it was "possible to properly regulate the air supply by observing the smoke condition," but this smoke condition is not defined; in Chicago we are very interested in it. From observations of similar settings, the writer would expect objectionable smoke except at low ratings, and I would inquire as to the performance in this regard. At what ratings would the stack violate the Chicago ordinance? It may be possible when individual stacks are used to regulate the stoker by the smoke, but the inconvenience of observation from the firing floor and the restricting smoke ordinances in most cities present objections to this practice.

I should like to inquire as to the steam consumption of the fan and stoker engine. On the Detroit Edison tests this item varied from 2½ per cent to 3½ per cent of the total steam developed. It would be interesting to know if the western fuel conditions cause any increase in this percentage.

No mention is made in this report of maintenance costs. It is quite possible that the installation has not been in operation a sufficient length of time to reach conclusions. However, the maintenance cost of this type of stoker is high

[1] Tests of Large Boilers at the Detroit Edison Company, D. S. Jacobus, Trans. Am. Soc. M. E., vol. 33, p. 565.

whenever pressure in the furnace chamber is obtained. The record submitted indicates the probability of pressure in the furnace as the average furnace suction in test No. 12 is indicated as low as 0.011 in. water, and to obtain an average so nearly neutral some observations must have indicated actual pressure in the furnace.

The New York Edison Company have repeatedly been reported by the press as having spent one-half million dollars for cost of equipping stack connections with cinder catchers to avoid a nuisance resulting from high forced blasts on stokers of the type being discussed. This company claimed at times as much as 3 per cent of their fuel was passed out of the furnace and lost as far as heating effects were concerned, 2 per cent of which was deposited in boiler passes and breechings and 1 per cent was actually discharged from the stacks. If such results occurred at Kewanee some of the heat balances reported are impossible.

A. Bement[1] wished to know whether the total or the available hydrogen contained in the coal was considered when calculating the loss, due to the water formed by this constituent in the products of combustion. He also asked how the fires were cleaned and how often. He expressed his opinion that the high results that were generally attained at the present time with boilers under test were due more especially to improvement in furnace design and in operation than to any of the other factors. Except for CO it was impossible to determine the loss due to combustible elements in the stack gases. Hence this item of loss had been charged to radiation, or radiation and unaccounted for losses, which made the matter of radiation a factor of very elastic proportions. He also commented on the fact that the tendency was to get low heat measurements with low capacities and high measurements with high capacities, due to the changing of the center of gas travel with different velocities and volumes. He stated that the question of the number of passes in a boiler was an important study and that the present tendency seemed to favor the four-pass arrangement as opposed to a lower number. He had designed a five-pass boiler with 18-ft. tubes, although he thought in such a design a 20-ft. tube would be more desirable.

F. G. Gasche[2] (written). In reviewing the paper by Mr. Bannister, a higher appreciation of the results will follow the consideration of the difficulties attending the use of Illinois fuels high in ash and moisture content. These elements of a fuel are not simply inert materials so far as heat value is concerned, but they constitute a decided encumbrance in the effective utilization of the combustible matter. This detrimental influence of ash and moisture is being recognized by the growing practice of assigning a "figure of merit" to a given fuel such that the heat content is not the sole basis for estimating its value in commercial applications.

The success of Mr. Bannister in using a coal containing approximately 20 per cent ash and 15 per cent moisture with the accompanying boiler and furnace efficiency exceeding 80 per cent is probably without precedent in steam engineering in this region. Analysis of the heat balance for the 72-hour test reveals that the several elements leading to a higher boiler and furnace efficiency have been considered with unusual care. The exhibit is sufficient to warn the designer against radiation losses, high stack temperatures, poor furnace conditions and every other indulgence of past installations.

The especial precautions in the way of numerous corrections to leading results have the merit of strict conformity with the A. S. M. E. Code for conducting boiler tests. The application of these corrections will, no doubt, continue with due respect to their origin, but it would seem worth while to consider the measure of the performance of a boiler as a physicist would look on such an experiment. In this way a boiler test is to be considered chiefly as a measure of *rates* of delivery of coal, water and heat.

If the accumulating deliveries of fuel and water are recorded graphically with possibly hourly corrections for water levels, etc., there can be shown two curves for which an average inclination can be assigned. The *rates* of delivery of coal and water thus established would scarcely be affected by the corrections ordinarily applied to aggregate results of a boiler test. For nearly all purposes they could be ignored. This manner of deriving the results of boiler performance would eliminate or at least minimize the effect of conditions in the furnace at the start and at the finish of the test, which conditions frequently impair the significance of total quantities.

About ten years ago I succeeded in obtaining 78 per cent overall boiler and furnace efficiency by the use of dust fuel and a special type of furnace in connection with a water-tube boiler. Owing to difficulties in maintaining the furnace construction the process did not, at that time, develop into a commercial success, but the investigation was one of the early indications that, providing proper furnace conditions, it was possible to burn Illinois coal with its encumbrance of 18 per cent ash and about 14 per cent moisture with an excess air supply scarcely exceeding 12 per cent of the theoretical requirements of the fuel. Speaking as an individual, since I cannot claim the especial espionage or guidance of directive agencies in the steel business in the analysis of any phase of the power plant question, I will say that there are a number of steam boiler plants in the steel business where very commendable results are obtained. In coöperation with four engineers in lines of endeavor similar to my own I have had the privilege and the responsibility of reporting upon the physical condition and ostensible performance of a great many boiler plants connected with steel manufacturing. There are a number of such plants where the average monthly performance shows an overall boiler and furnace efficiency somewhat exceeding 70 per cent.

J. C. Bannister[1] (written). As the individual upon whom rests the responsibility for the actual economy of operation of this boiler plant, I am not so deeply concerned with what form the efficiency curve would assume under certain conditions, which have been suggested, or with what the discrepancies between government reports of the value of the combustible in Fulton County coal and the value of the combustible in the coal which was used in these tests, as determined by our actual analyses, were; but I am deeply concerned in the actual daily operating efficiency of this plant and the actual amount of coal, such as it is, which is being consumed. For this purpose, and anticipating some questions along this line, a very careful record has been kept during the months of October, November and December, cov-

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[2] Mechanical Engineer, Illinois Steel Company, Chicago, Ill.

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ering the actual operation of this boiler house, with a calculation of the evaporation and coal consumed per boiler horsepower-hour during those months. I have these figures before me, but before giving them to you I think it would be well to state to you what the real problem was which confronted us when this boiler house was designed.

First of all, our loads are practically constant for any one day of operation. We have a slight increase during dark weather and during the winter months at morning and evening, due to the lighting load, but the load curve is comparatively flat throughout each working turn. For this reason it was not necessary to take into account so strictly the capacity of the proposed installation for handling enormous peaks by running the boilers at extreme overloads, as it is in the case of lighting and railway plants. We had to provide for a maximum demand of from 2700 to 3000 boiler horsepower, using only three of the four boilers at any one time. This meant that at the worst no boiler would be called upon to develop more than $166^2/_3$ per cent of its rated capacity. We also knew that we would be obliged to burn a fuel in the form of slack, which at the very best would not contain more than from 9300 to 9700 B.t.u. per lb. as fired, and that this fuel would contain from 13 per cent to 16 per cent moisture and from 19 per cent to 22 per cent ash, with about $4^1/_2$ per cent hydrogen and $3^1/_3$ per cent sulphur. We also knew that it would be possible, on account of the nature of the prime movers in the plant, to use only a limited amount of superheat and very moderate pressures, and that the only exhaust steam available for feedwater would be from the pumps and fan engines. Considering all these things, the apparatus which was selected, and which has been described in this paper, seemed to us to be most suitable to our needs. It may be that equally good results could have been obtained with other equipment, with this same fuel, but I question whether it has ever been done.

The tests which were made last spring were, as the author has stated, for the purpose only of proving contract guarantees, and were admittedly too short to be used as a basis for final conclusions. They were, however, of such a gratifying character that we have been importuned by not only interested parties, but many disinterested parties, to give the results publicity. Before doing so we felt it necessary to conduct the test which was made in October, and which was of sufficient length and so surrounded with all of the possible safeguards as to make us feel sure that the result obtained would be unquestionable. The author has given these results in his paper, has pointed out what seemed to him the operating causes for the high efficiency, and has also suggested some possible conclusions which may be arrived at from this test under conditions somewhat dissimilar from those under which the test was conducted. Whether he is right in those conclusions or not may be a question in some minds, but I think there can be no question as to the conclusions reached upon the test itself. Furthermore, I am glad to be able to report that the operations during the three months of which I have spoken, October, November and December, have also shown very gratifying efficiencies. The figures which follow are compiled from the accounting department's records for these months.

First, as to the evaporation: We have two checks upon the water fed to our boilers. In the first place it is all measured through venturi meters which have been calibrated by weighing tests and the integration of these meters is corrected for temperature and a slight inherent error. We compare these meter readings with the actual measurements of water fed to our purifying plant, which is an intermittent system and into which the water is correctly measured in 60,000 gal. units. The discrepancy between the results obtained through these two methods is surprisingly small. From the total water fed thus obtained we deduct a certain amount, which has been predetermined by experiment, for the water blown down and used in refilling boilers; and thus obtain, approximately, these amounts of water actually evaporated for the respective months: October, 26,514,200 lb.; November, 19,278,750 lb.; December, 20,428,550 lb.

On our coal we also have two checks. One of these is the actual weights of coal delivered to the boiler house as taken from the mine weights and the weights reported by the official weighmaster at Kewanee, deducting at the end of each month the excess on hand over stock inventoried as on hand at the beginning of the month. Second, we have found during the entire period of all of the tests which we have run, covering altogether 172 hours, during which coal was actually weighed, that the total weight of coal so weighed to the stokers divided by the total number of revolutions of the stokers resulted in a constant factor of $110^1/_2$ lb. Each stoker is equipped with a revolution counter, and readings are taken from these counters daily. At the end of the month the aggregate revolutions multiplied by $110^1/_2$ gives the total amount of coal fed to the stokers. It may be a surprise to learn that the discrepancy between the calculated weights as derived from the shipping weights and the monthly inventory, and that derived from the revolutions of the stokers, has been for the three months in question less than 1 per cent of the total.

From these data the water fed to the boilers, as determined by the methods described above, and the coal as determined by the methods just cited, we arrive at the coal consumed per boiler horsepower-hour for these three months, which has been: 4.53 lb. in October, 4.71 lb. in November, and 4.49 lb. in December. The average evaporation for the three months per pound of coal fired was 6.902 lb.

Now, using the same figures for water and coal, and allowing to the coal as fired an average value of 9500 B.t.u. per lb., the operating efficiencies have been 77.7 per cent in October, 76.3 per cent in November, and 78.5 per cent in December. The actual hours during which these boilers were fired during these three months were 1165, 1077 and 987, aggregating 3229 hours, which is only 49 per cent of the total hours for three boilers during those three months. When it is considered, also, that the three months in question were not ones of the highest activity in our business, so that while three boilers were in use on some days and only one on others, and that it was only necessary to fire one or two boilers at any time during the night turns, all of which added to the standby losses during this period, I think it will be admitted that the operating efficiencies have been fairly satisfactory and compare favorably, conditions considered, with the efficiency obtained in the 72-hour test. While we realize that our former steam plants were by no means economical, personally I cannot help feeling a sense of pleasure in the fact that this installation has already begun to save us in the matter of fuel alone at the rate of at least $30,000 per year, or at the rate of more than $10 per horsepower-year.

THE AUTHOR. If we could incorporate Mr. Harrington's

"ideal or actual efficiency" in the boiler code, as advanced by The American Society of Mechanical Engineers, I would be greatly pleased, and am ready to use such a standard for all boiler tests. Whether or not the theory advanced by Mr. Harrington that the radiation and miscellaneous loss increases with the load is correct, I frankly confess a lack of knowledge of flame propagation which would decide this question. However, it is hardly logical to use the actual radiation and miscellaneous loss for each test, as these figures are based upon tests which are admittedly too short to be reliable. We know that this item of radiation and miscellaneous loss is made up chiefly of two losses: one due to radiation from exposed surfaces, the second due to unconsumed hydrocarbons. The first loss is certain to increase with the load, if expressed in absolute heat units, but when expressed in percentage of heat in coal burned, the loss decreases with the increase in rate of firing. The second loss is indeterminate as it cannot be measured by the usual test methods. This second loss may or may not increase with the load, depending upon the nature of combustion in the combustion chamber, and whether or not the maximum furnace efficiency or combustion chamber efficiency was exceeded in these tests is an open question. However, both the actual and created efficiency figures are submitted in the report so there need be no serious difficulty arising from this point of disagreement.

I do not know what the steam consumption of the fan engine was. As these tests were conducted to determine only the boiler, furnace and stoker efficiency, the net efficiency of the plant was not considered. Had the net efficiency of the plant been considered I would still disagree with Mr. Bryden in his statement that from 2½ per cent to 3½ per cent should be subtracted from the efficiency figures as shown, due to the steam consumed by the fan engine, as this steam after losing perhaps 7 per cent of its heat energy is delivered to the feedwater heater, which consumes all of this steam. Thus a very small portion of the fan engine steam is lost as that heat which is put into the feedwater would otherwise be supplied by the boiler for which coal would be burned. In some instances where sufficient exhaust steam is available to heat feedwater without the use of exhaust from the fan engine, there would be an appreciable loss, due to this steam consumption, but I believe that each case must be considered separately in order to establish the value of steam used by fan engines. It would also be logical to consider steam consumed by feedwater pumps in figuring the net efficiency of the plant.

Since the tests were made the steam consumption of the soot blowers has been found to be at the rate of 43,200 lb. per hour per boiler. The tubes on each boiler are blown for about 10 seconds at a time at 8-hour intervals, which gives a total consumption of 360 lb. per boiler per day.

Little or no difficulty has been experienced in handling ash or clinkers since the method of handling has been worked out and a system adopted which allows for dumping before a hot clinker has worked across a dumping plate and become glued to the bridgewall. It would be a very simple matter to make this clinkering a burdensome process if the proper time for dumping the clinker were not observed. As to the frequency of dumping, the following figures will serve to illustrate approximately:

"Ash and refuse represents approximately 25 per cent of dry coal fired, and 1100 lb. of ash are dumped at each cleaning period. Thus approximately four times as much weight in coal is fired as is represented by the weight of the ash, or 4400 lb. of coal per period of cleaning. Knowing the rate of firing, the length of cleaning period may be established."

As stated in the text of the report, pop-offs occurred through the pop-valves on the boiler proper, although there is a pop-valve on the superheater outlet, which originally was set several pounds below the valves on the boiler proper, but due to a slight accident to this superheater valve it was not set in this way for the tests.

Contrary to Mr. Marsh's belief, that objectionable smoke occurred except at the lowest loads, it may be stated that with the increase in load the ease with which no smoke may be maintained is increased. At no load was it at all difficult to maintain combustion without any apparent smoke. However, I have found that the point of most efficient combustion occurs when there is a slight haze of smoke over the stack, which shows up as the amount of blast is reduced after the fire has been burning without smoke. No trouble has been experienced in blowing cinder out of the stack. Considerable fine ash is blown over the first baffle and some is carried to the base of the stack, but we have observed no similar deposit of ash outside the gas passages.

Answering Mr. Marsh as to the kind of calorimeter used in analyzing the coal, R. W. Hunt & Company used a Mahler-Atwater oxygen bomb, and the National Tube Company a Parr calorimeter, which has been thoroughly checked by standard methods and which gave figures that compared very well with those given by R. W. Hunt & Company, on similar coal samples.

In calculating the heat loss due to burning hydrogen in coal, the total hydrogen was used as we had this figure from our ultimate analyses but had no analyses which showed the chemical combination of this hydrogen with other elements.

One of the chief items of saving made possible by the installation of the boiler house described in this report was that of labor. During the 12-hour day shift one man handles all the coal and ash that must be handled for the 24 hours. This means removing all the coal from the cars and placing in the bunkers, and removing ash from bunkers under stokers, and placing in cars for shipment. There are at all times two men upon the boiler and auxiliary room floor. Thus we have during the 24 hours five men who do all the required work in connection with this plant, including cleaning idle boilers and small repairs, each man working 12 hours.

LARGE STEAM POWER PLANTS

Abstract of Topical Discussion Presented at the Chicago Meeting, March 18, 1914, by I. E. Moultrop, J. W. Parker, John Hunter and W. L. Abbott

I. E. MOULTROP's talk concerned the boiler room, to which the present-day engineer is directing a great deal of attention to secure better economy. This is as it should be, because the operation of the boiler room will show in increased fuel economy the increase of skill and intelligence devoted to that part of the plant.

The majority of plants are subject to great and sudden variations in load. In the electrical end of the station there are all sorts of instruments which are closely accurate, but only recently has some thought been given to installing instruments in the boiler room. Originally, all that a man had was a water glass and a steam gage. A visual load indicator was then added and the next instrument was a device that has created a lot of discussion, the CO_2 recorder. This is a delicate instrument, and where it has been put into the boiler plant and received the best of care and attention, it has been of some use. But it is naturally a laboratory instrument and not for the average fireman. The difficulty is to get a fair sample, as the qualities vary greatly in different parts of the cross-section of the gas passage. A sample taken from one place may be very different from that taken from another point in the same flue at the same time.

One of the most satisfactory instruments now in use is the steamflow meter. Using it in connection with draft gages, draft regulators, feedwater regulators, etc., the fireman can operate a boiler plant with much intelligence.

In the usual large station a high chimney is necessary to carry off the gases. Ordinarily the height required for this purpose is enough to give the draft needed under normal conditions. But the exacting requirements of public utility plants call for more positive control over the draft, and ability to meet sudden demands for load calls for forced-draft apparatus.

A good arrangement is a plant that will run on natural draft, with some cheap apparatus for increasing materially the draft to meet peak loads or unexpected demands. At the L Street Station in Boston the situation has been met by using Murphy stokers, closing up the ashpit and creating forced draft with steam jets. The load is carried on natural draft up to 150 per cent of rating. Above that the ashpit doors are closed, the steam blower turned on and it is possible to reach 300 per cent of rating, or over. Boilers have been taken from 125 up to 300 per cent inside of 5 minutes.

In the past too much attention has been given to the operation of the turbine or engine room and not enough to the boiler plant. The usual practice has been to put the high-priced and high-grade engineer in charge of the generating room and hire some brawny individual to shovel coal into the boiler. The economy of the turbine room is mostly in the hands of the designing engineer. In the fire room the constructing engineer does not have much control over the economy. When it is considered that from 60 to 70 per cent of the cost of putting a unit of electrical energy upon the bus bars is spent in the fire room it does seem that this is the place to have the most skilled help. The fire-room job has been dirty, under-paid, uncomfortable, unpleasant and unattractive in every respect. The mechanical stoker has changed this in many respects. The boiler room should be arranged to do away with all of the manual labor, make the place light and clean, and give the man in the fire room sufficient instruments so that he can tell what he is doing. This will make the job attractive to a young man and it will be possible to get better help in the fire room.

J. W. PARKER spoke of the immense units at the Delray plant of the Detroit Edison Company and their operation, and those to be installed at their new station at Conners Creek. It was his opinion that the large boiler had created a good deal of criticism just because it was large. Some people object to putting so many eggs into one basket, but quoting from Mark Twain, he preferred to put them all into one basket and watch the basket. Boilers are more reliable units than steam turbines. It is possible to lose a large turbine much quicker than a large boiler. The company had never lost one of its large boilers when it was needed, and during a peak, never had a tube burst.

As to tube troubles, the water was not very bad. In a year or 18 months, upon opening a boiler about $^1/_{16}$ in. of sulphate scale was found on the front tubes. With a unit driven only during the peak at about 175 per cent of rating, $^1/_{16}$ in. of scale is not serious, but with the double-ended boiler the trouble from radiation seems to be greater. Everything is radiating right at the front tubes and when running at 200 per cent of rating very little scale is permissible. The only trouble in this direction had been a small bag about the size of a quarter and this was not discovered until the unit had been cut out and inspected.

Even $^1/_{16}$ in. of scale is too much to stand for, however, and the water should be cleaner. A small amount of barium hydrate had been used but Mr. Parker was in favor of using distilled water for make-up. It does not cost much except the radiation from the distilling apparatus because it is possible to distill the make-up under vacuum. By using it the amount of blow-off can be reduced to 2 per cent. Trouble from corrosion can be lessened by feeding a certain amount of lime into the boiler.

In reply to a question by Mr. Hunter the speaker said that they had used compound much as people buy

Presented at the Chicago local meeting of The American Society of Mechanical Engineers on March 18, 1914.

and take patent medicine, getting enough foam to cause flooding of the superheater tubes and their constant burning. The barium hydrate is fed in the same way as any compound and it controls the scale formation in the same way, but avoids foaming. The barium sulphite precipitate was so fine that it could not be filtered out, and they were using a little sodium in combination with it, but this compound was simply used as a makeshift until the experiments on the practicability of using distilled water for make-up had been worked out.

One of the advantages of a large boiler is that the company can afford to use more instruments, employ better men and thus pay more attention to each single boiler unit.

The Detroit Edison has just started the foundations for a station of 120,000 kw. normal capacity. It will have 12 boilers of which each will ordinarily care for 10,000 kw., and there will be no spares in the plant. By installing forced-draft apparatus and by taking care that the stacks and breeching are ample, it will be possible to get 250 per cent of rating out of each boiler. Each turbine is served by two units and running at the above rate one boiler out of every four could be spared.

The boilers at Delray have done so much more than was expected of them that there is too much boiler capacity. During the peak season of 1913 no banked boilers were carried, which, of course, means a large saving. It is hard to realize how much of a disadvantage a low load factor is. Boilers which show high efficiency under a constant load will not show up as well under variable conditions.

To take advantage of the possibilities of large units it is necessary to study conditions. At Delray they started in with boiler tests and studied carefully the things that seemed to be indicative of good efficiency. In this connection the CO_2 machine has been a most valuable instrument. They had been able to keep it running and firemen trusted it. Samples are drawn from four different points in the setting and are mixed automatically to obtain an average sample. The recorder is mounted on the front of the boiler where the firemen can watch it. There are also steam-flow meters and draft gages, but Mr. Parker did not know of any better instrument than the CO_2 recorder to show good firing and poor firing conditions. The flame is watched where it leaves the furnace and enters the first pass. If there is a slight haze there it means that there is some slight flame over in the pass, and if it gets a little bit heavier there is danger that the gases will be cooled down and go out before the combustion is complete.

It is possible to get a beautiful looking combustion chamber and a good looking second pass by using an excess of air and still have bad combustion. There is no better way to detect it than by the use of the CO_2 machine. From 13½ to 14 per cent of CO_2 is obtained as an average when the boilers are running steadily. Conditions are disturbed a little about noon and the records show perhaps 10 per cent. As the boilers are run harder the CO_2 rises. It is common to get 16 to 16½ per cent at 225 per cent load, and checking with the Orsat, there is no more than a trace of CO. It is not a good idea to draw two lines on the CO_2 chart and tell the men to keep between them.

As at first installed the control apparatus of the big boilers was clumsy to handle. The damper was handled from a gallery 20 ft. above the men's heads. They had no steam-flow meter. Efforts have been made ever since to bring the control under the hand of the fireman so that he will have all the advantage that a testing engineer has when he is running a test on a boiler. The men can control everything from one point and all the instruments are on one board.

It has naturally come about that everything is hand-controlled and automatic regulation has not been tried because it was desired first to find out what there was to do. It would then be easy and desirable to install automatic apparatus.

With hand control it is possible for one fireman to handle two of these large boilers. In addition there is a roving fireman over every nine boilers. Firemen who have been in the service 2 or 2½ years are receiving 40 cents an hour and the company is rapidly getting to a point where the highest priced and brainiest men must be placed in the boiler room. Ordinarily a change from the boiler room to the engine room has been considered a promotion, but under the new conditions the engine room will have dropped to a secondary place. In making transfers it is important that the men realize this, as otherwise there is apt to be trouble and dissatisfaction.

As expressed by Mr. Stott at the annual meeting of the Society in New York, it would be a fine thing to have college graduates for firemen. This is not impossible by any means: the dirty work could be handed over to helpers and the real brain work entrusted to them. A preliminary training of this kind in the boiler room for a year would be invaluable and to the right kind of a man the job would be so interesting and worth while that he would be willing to do the actual firing.

John Hunter spoke of the construction and development of large steam power plants: In St. Louis this line of work has been arrested for the past two years due to the development of the large hydroelectric plant at Keokuk, from which 60,000 h.p. is transmitted over two transmission lines, at 110,000 volts, to St. Louis, a distance of 145 miles. At a substation in St. Louis County this is stepped down to 13,200 volts, 30,000 h.p. being delivered to the street railways company and 30,000 h.p. to the lighting company. The lighting company's energy is carried underground at this voltage, a distance of 7 miles, to a substation adjacent to the main steam generating plant, where it is stepped down to the steam-generating voltage of 6600. In the

steam station there are three distinct systems of service: the street railways 25-cycle, the Union Company's service for industrial power and business lighting, which is changed to direct current, and 60-cycle service for residence lighting. The water power energy is connected directly onto the present bus bars of the steam generating system, the two systems floating together in parallel.

To insure continuity of service the steam station has been maintained as a standby ready to pick up the water power load in the shortest possible time. The prime movers are either in on the bus bars, or floating, ready to pick up the load, which is an easy method of operation. The condition is much different in the boiler room. It was found from test that it would take 130 lb. of coal per hour to bank the fires in each boiler and hold it at about 60 lb. steam pressure, and as all of the boilers are equipped with chain grates, which are slow-moving units, it would require about 30 minutes to bring them in on the header with the fires in such condition that they could maintain the desired capacity.

To bring the boilers quickly into service at less cost a unique system of keeping the water hot in the reserve boilers with fuel set on the grates ready to ignite at a moment's notice was developed. A tank with a steam coil was placed in the basement directly below the battery of standby boilers. The blowoff headers from these boilers were connected to the bottom of the tank and the top to the superheater connections to the steam drums. The difference in elevation of these two connections to the boilers caused an easy circulation. The steam coil in the tank was connected to a drain of one of the main steam headers of the standby boilers which were kept alive for emergency service. This connection not only served to drain the header but also to heat the water for the idle boilers, and maintain it at a temperature of about 212 deg. fahr. at a cost by test of the heat equivalent of about 12½ lb. of coal per hour. The boilers can be cut into service and maintain their capacity in about 15 minutes.

Quick ignition of the fires has been solved by laying on the grates, which are 10 ft. by 10 ft., two rolls of oily rags, crosswise and lengthwise, covering the remainder of the grate with a high-grade washed nut coal about 1½ in. in size to a thickness of 9 in. Kindling wood soaked in oil is placed on the top of the coal. This fuel may stand any length of time without fear of deterioration or cost. On ignition it quickly bursts into flame and the generation of steam is thence rapid.

In maintaining hot water in standby boilers it is important to keep the dampers tight so that there is no circulation of air in the boiler. In this way the brick setting is kept hot. The fire brick suffers little from the heavy action of the flames when the fires are started. One complication which arose during the past six months was a pitting action in the drums. Most of this pitting was in the vicinity of the water line and evidently was the result of galvanic action between the metal of the boiler drums proper and particles of carbonaceous matter adhering thereto. Further action was prevented by cleaning out the corroded spots, scraping and wire-brushing the entire inside of the drums and applying two coats of graphite paint, permitting each coat to dry thoroughly.

To prevent the possibility of further action of this sort, the method of treating the boiler feedwater was changed. The plant in St. Louis is on the banks of the Mississippi River, which contains a high percentage of silt, sand and organic matter. This water is clarified for boiler purposes with a coagulent of lime and sulphate of iron, adding a small percentage of soda ash to relieve it of its permanent hardness. The use of this soda ash results in the concentration of sodium sulphate in the boilers, and as this is strongly alkaline, it was thought that it served as an electrolyte for the galvanic action taking place between the particles of carbon and the iron. The company has just begun using barium hydrate instead of soda ash to remove all of the organic matter and a large portion of the sulphate, or permanent hardness, from the water before it enters the boiler, at the same time avoiding the presence of an alkaline solution in the boilers.

Mr. Hunter then referred to an experience with the cooling coils in the high-tension transformers of the hydroelectric system. The coils in these transformers were of iron, and although the current was alternating it was found that the coils were in a strong magnetic field and were highly magnetized. After being in service for six months the inside of the coils had deteriorated rapidly, indicating galvanic action. The pipes had also become heavily coated on the inside with mud, which had been deposited from the water flowing through them. The deterioration and accumulation of mud forced a change from iron to brass coils in the transformers and in these there is no accumulation of any kind.

The effect water-power operation had on the coal supply on the St. Louis market is interesting. A year ago at the Ashley St. station before the water-power service went into effect, something over 1100 tons of coal per day was burned; now only one-half of that amount is used. This falling off in the coal consumption by the lighting company and a like amount by the street railways company caused a large amount of screenings to be thrown on the market, which effectively lowered the prices of all screenings shipped from the mines in the vicinity. The railroads handling this coal and also the Terminal Railroad Association suffered a material loss by the reduction in the number of cars of coal handled per day.

Previous to receiving water power, the peak load in the Ashley Street plant was 55,000 kw., which required

a crew of 122 men for operation only, including coal and ash handling. The steam-generated peak this winter, in addition to the water power received, was 34,400 kw. The operating crew for this load and for emergency service in case the water power should fail and the station be required to pick up the entire load, is 87 men.

Through the increasing demand for energy the installation of new machinery in the Ashley Street station brought about many points that had to be worked out to meet the special conditions there. Among these were the condensers originally installed for the 5000-kw. units, which with their auxiliaries afterward served the 12,000-kw. turbines. The ratio of cooling surface to capacity on the old units was 4 to 1, while on the new installations it was reduced to 1.6. With the old condensers and the larger load there was a serious congestion in the upper bank of tubes. To relieve this congestion and trouble with packing leaks caused by the vibration of the tubes due to the high velocity of the steam, it was necessary to open up the top and center banks, taking out three rows of tubes in three places on both banks. This permitted the steam to be carried well down into the condenser and materially relieved the high velocities, giving a much closer balance in pressure between the top and bottom of the condenser and at the same time obviating all trouble in the packing at the tube ends.

A point worth mentioning in connection with the steam end of the 12,000-kw. turbines, was a weakness that developed in the third stage diaphragm nozzles. This, in Mr. Hunter's opinion, was brought about by the unequal expansion in the diaphragms, causing the thin nozzle plates to crack and in some cases to break out. This weakness was overcome by a change in the design, the nozzles being cast of brass in sectional plates. These plates, being portable, can be removed without dismantling the machine, although with the new design it was thought that it would never be necessary to remove the sections. Outside of this weakness the operation of these turbines has been most satisfactory, and the maintenance cost practically nil.

It would appear with the advance in the art and the higher capacities of machines being manufactured that the leaning is toward the horizontal machine. Some two years ago two 4000-kw. units were installed in the station and have given excellent satisfaction. The 20,000-kw. unit now being contemplated will be located in the space occupied by a vertical cross-compound reciprocating engine of 3000-kw. capacity, and as the demand for energy increases, 20,000-kw. units can be installed in the space now occupied by two other 3000-kw. reciprocating engines. This prime mover capacity, of course, will be governed by the space available in the station for additional boilers.

W. L. Abbott agreed with the preceding speakers that the boiler room was a very good place to start in order to reduce the cost of producing electrical energy. A boiler with its furnace he had frequently described as a piece of apparatus for the purpose of heating air and cooling it. The air is a medium for transferring heat from the fuel to the water in the boiler. Suppose a transfer of water was being made from one vessel to another and the cup with which the transfer was made each time was completely filled and emptied, there would be no loss. Filling the cup in one vessel, emptying two-thirds of it into the other and throwing the balance away would duplicate what is being done in the boiler room. Air is taken at a normal temperature, heated up to 2000 or 2500 deg., and cooled down to 500 or 600 deg. The rest of the heat is used to create a draft. That is, the air is driven up a smokestack, pulling fresh air after it through the fuel bed. To use 20 per cent of the heat of the fuel merely to push air through the fuel bed is a wasteful process. It is true that the temperature of the water in the boiler is some 400 deg. and cannot cool down the air. The remedy is to use economizers and cool down the furnace gases to the lowest point possible. Mr. Abbott would therefore abolish smokestacks for the purpose of creating draft. Boilers are being forced to 100 per cent overload every day with natural draft and with forced draft frequently from 300 to 400 per cent overload, and still the limit has not been reached. The speaker suggested that the boiler be cut in two, and half of it be forced to 500 per cent if necessary. The other half could be used as an economizer in two stages if need be and the gases cooled to the temperature of the feedwater. In this way there is a possible saving of 20 per cent.

Another medium for transferring energy is steam. It is loaded up with heat in the boiler and in the superheater and then in expanding it through the turbine the attempt is made to get back from the steam as much of that heat as is theoretically possible. Here is the place where practice fails. Conceive a sawmill steam plant with a leaky tea kettle of a boiler, the engine out of line and without any packing. Compare that with the modern high-pressure, low-vacuum turbine installation, and an approximate comparison between the thermal efficiency of the modern equipment and the actual amount of energy in the steam is obtained. To get from the steam as it goes through the turbine 20 per cent of its energy is doing very well. Four-fifths of it goes to the condenser. The only way to get a greater percentage of this heat is by raising the initial pressure and temperature of the steam as it enters the turbine and by reducing the final pressure and temperature of the steam as it leaves the turbine. Progress is being made slowly in the higher pressures and temperatures but the possible saving in this direction is small as a little increase in the temperature is accompanied by a considerable increase in pressure.

On the other end it is common to discharge the steam

into the condenser at a pressure one or two pounds above absolute. This looks to be inconsequential compared with 200 lb. initial pressure, but in this one or two pounds pressure which have been sacrificed at the lower end are 50 or 75 deg. of temperature, and this is a waste for which the engineering fraternity can make no apology. It appeared to the speaker that there had been less horse sense employed in the design of condensers than in any other part of the steam equipment. The manufacturers seem to think that a condenser is like a boiler and that its purpose is to cool off rather than to condense the steam and so it is passed up and down through a bank of thickly spaced tubes at a velocity almost equal to that of a high-powered bullet, for they seem to think that what is good practice in a boiler must be good practice in a condenser. The steam can only get through by piling up a back pressure.

To obtain greater economy in the engine room, make a condenser having the greatest possible area for the steam to strike the tubes, so that all of the cooling surface is immediately available for the steam when it enters the condenser. Instead of passing the steam through a long constricted passage full of baffles let it get at once in contact with the cooling surface at low velocity and be condensed without loss of pressure. A gain of 1½ in. of vacuum represents a possible increase of 25 per cent in the power from the turbine.

Two other suggestions were made for increasing the efficiency. The cost to put current on the bus bars does not consist alone of operating costs. It consists equally as much of the fixed charges on the cost of the powerhouse and equipment. Take the cost of operation of a plant, multiply it by two, and the cost of operation plus the fixed charges will be obtained. This more nearly represents the cost of the output. For a further reduction of this cost reduce the cost of the powerhouse. This is a bright idea that perhaps would not occur to the gentlemen designing powerhouses. In putting on some filagree and perhaps a steeple, they do not realize that they are loading up that powerhouse and that community with an increased cost on all the energy to be made in future years.

To get the lowest cost the equipment cannot be duplicated to guard against every conceivable contingency which may occur in this decade or the next. The size of the average powerhouse, and the amount of equipment in it should be reduced. With the usual power factor the apparatus on the average is busy about one-third of the time. About one-fourth of the apparatus is busy only 2 or 3 per cent of the time. In the course of the year, if the powerhouse is fully loaded at the time of maximum load, there is only 100 hours or 200 hours that the whole of the equipment is used. That last quarter of the equipment should not be installed but the peak load should be carried as an overload on the rest of the equipment. Then by reducing the cost of the powerhouse by one-quarter the cost of the output will be cut 12½ per cent.

NECROLOGY

M. L. JENKINS

M. L. Jenkins was born February 26, 1865, at Walworth, Wis. He received his education at Delavan, Wis., and served an apprenticeship as toolmaker with the Wilson Sewing Machine Company, Chicago, Ill. This experience was followed by brief periods as machinist with such companies as the Chicago Steam Engine Works, Chicago Die & Machine Works, A. H. Andrews & Company, and Wheeler & Tappan. In 1881 he was made foreman of the last named concern and two years later was promoted to superintendent, in which position he was in charge of all design. In 1891 Mr. Jenkins was made superintendent of the Gardner Steam Pump Company of Quincy, Ill., and in this connection designed and built a line of duplex steam pumps. In 1893 he became superintendent of Fairbanks Morse & Company, Beloit, Wis., where he engaged in the manufacture of gas and gasolene engines, steam pumps, hoisting engines and power transmitting machinery. He was for a time shop superintendent of Allis-Chalmers Company, Milwaukee, Wis., and in 1905 became associated with the Buda Company, Harvey, Ill., in the capacities of superintendent and general manager. His inventions and developments during this period covered miscellaneous gas engines for automobiles, commercial cars, and railroad motor cars, as well as miscellaneous types of operating mechanism used in connection with them, such as transmissions, etc., and the designing of original ideas as worked out by him in connection with tools for accuracy in production work and manufacturing. He died March 2, 1914.

ALBERT STEARNS

Albert Stearns was born in Rindge, N. H., December 20, 1833. When 21 years of age he was appointed to serve on the metropolitan police force in Brooklyn, N. Y., and six years later received the rank of sergeant. At the outbreak of the Civil War, he temporarily resigned this position to organize Company I of the 131st Regiment, New York Volunteers. He served with distinction throughout the war: while in Louisiana, as provost marshal and judge, also as sheriff, Department of the Gulf; and as military street commissioner in Savannah, Ga. His labors there were commended by Gen. William T. Sherman in his published report of May 9, 1865. He was slightly wounded at the battle of Cedar Creek and was brevetted a major for bravery in action. Major Stearns was the author of a book, Reminiscences of the Late War, which gives an entertaining account of the years spent in his country's service. At the conclusion of the war he was offered the rank of captain in the metropolitan police force, a position he retained until 1870. In that year he became connected with Church & Company, Syracuse, N. Y., manufacturers of bicarbonate of soda, and for 33 years served them as superintendent of factories and chemical works, as inventor of labor-saving devices and machines, and also as purchasing agent and confidential advisor. After the consolidation of Church & Company with the John Dwight Company, chemical manufacturers, Mr. Stearns became superintendent of the new concern, the Church & Dwight Company. This position he held for 17 years. He retired from active work in April, 1913, and returned to Brooklyn, N. Y. He died April 21, 1914.

MEETINGS

CINCINNATI, APRIL 23

A joint meeting of the Cincinnati Section and the Engineers Club of Cincinnati was held in that city on April 23, 1914. A. L. Jenkins read a paper on the Beginning and Development of the Machine Tool Industry in Cincinnati. The first large machine shop appears to have been that of Miles Greenwood, who came to this country from England. John Steptoe, also an Englishman, the first tool builder of Cincinnati, came there shortly after 1848. The paper was discussed by H. M. Lane, H. M. Norris, A. J. Baker.

A second paper, Reinforced Concrete, was read by Ludwig Eid, in which he traced the development of its use from its early beginnings in France. After a discussion of the properties desirable in the steel, cement, sand, and pebble or stone, the author devoted some time to consideration of local materials and to the proportion of the mix. An animated discussion followed. Owing to lack of time a third paper, Recent Developments in Smoke Abatement, by A. G. Hall, was omitted.

PROVIDENCE DINNER, APRIL 29

The annual joint meeting of the Providence Association of Mechanical Engineers with the Society took the usual form of a dinner, held in Providence on April 29. It was the largest in the history of the organization, being attended by over 250. After addresses by the President and Secretary of the Society, an interesting lecture on the Manufacture of Tubing was delivered by Harold T. Miller of the National Tube Company. This was illustrated by moving pictures representing the entire industrial process of tubing manufacture.

PHILADELPHIA, APRIL 30

A joint meeting of the Philadelphia Section of the Society and of the Franklin Institute was held on April 30. C. D. Young, Mem.Am.Soc.M.E., presented a paper on Locomotive Superheaters and Their Performance, which treated of the development of the superheater as applied to early locomotives and of its application to modern locomotives. The results obtained from exhaustive experiments at the Pennsylvania Railroad Company's testing plant at Altoona to determine the comparative economy of superheated and saturated steam were given, and also the results of operation on the road were analyzed as well. The paper was well illustrated with lantern slides.

QUARTERLY MEETING AT NEW HAVEN, MAY 1

The spring meeting of the New Haven Section was held in the Mason Laboratory, Sheffield Scientific School, New Haven, on the afternoon and evening of May 1, 1914, with Aeronautics and the Internal-Combustion Motor as the subject. The meetings were largely attended by local engineers, and a delegation of members of the Aero Club of America stopped off to attend the meeting on their way to Marblehead to participate in a demonstration of the Burgess-Dunne hydro-aeroplane.

E. S. Cooley tendered his resignation as chairman of the Committee on Meetings, which was regretfully accepted.

John J. Long of Brown University read an illustrated paper, A Review of Aeronautical Progress. The Proportions of Propellers and Engine Cylinders was discussed by David L. Gallup, and a paper on Fuels for Internal-Combustion Engines was presented by D. B. Pangburn. A letter was read from Everard Thompson of the Connecticut Aeroplane Company who was unable to attend the meeting. Joseph A. Steinmetz of Philadelphia spoke on Aircraft in War for Offense and Defense. A 100-h.p. Gnome aeronautical motor was on exhibition in the laboratory, having been loaned for the meeting by Edson F. Gallaudet of Norwich, Conn.

At six o'clock a dinner was served in the Yale dining hall to about fifty of the members.

The evening session convened about eight o'clock, with Prof. L. P. Breckenridge as chairman. James Hartness, President of the Society, made a few general remarks, and Calvin W. Rice, Secretary, spoke appreciatively of Mr. Cooley's work as chairman of the New Haven committee.

The Evolution and Status of Aeronautics was the subject of an illustrated paper by Henry Woodhouse, editor of Flying, and Howard Huntingdon of New York read an illustrated paper on Internal-Combustion Motors in the Field of Aviation. Mr. Steinmetz spoke informally on certain aspects of aviation and Edgar Beecher Bronson, author, explorer and aeronaut, told of some interesting experiences in Africa and South America.

ST. LOUIS, MAY 4

The St. Louis Section entertained the Associated Engineering Societies of St. Louis, on May 4, at the Hamilton Hotel. An illustrated lecture was given by Arthur Seubert, Through Germany with the A.S.M.E., which was followed by a general reception. Lantern slides made from photographs taken during the trip were used and Mr. Seubert, who attended the meeting in Germany, gave an interesting account. The occasion was made a Ladies' Night and proved a decided success.

SAN FRANCISCO, MAY 6

A meeting of the San Francisco Section was held in the Engineers Club on May 6. After a brief business meeting, a paper on the Stationary Diesel Engine was presented by Herbert Haas, in which he described the Diesel cycle, both two-stroke and four-stroke, and the standard types in both the horizontal and vertical engines. This was illustrated by lantern slides.

A. M. Hunt drew attention to what he considered the chief factor militating against the successful introduction of the Diesel engine in this country, namely the desire on the part of American designers to add improvements, instead of accepting European practice. Unsatisfactory operation was the result.

A. H. Babcock, consulting electrical engineer for the Southern Pacific Railway, followed, and cited two installations made by his company, where the trouble lay in the fact that stress was laid on the high economy in fuel consumption, without regard to the other features, including the cost of producing a horsepower. Upon placing a wattmeter in the electrical circuit it was determined that all the work done by the engine, rated at 100 h.p., could have been accomplished with 30 h.p. In conclusion, he paid a strong

tribute to the modern Diesel engine with special reference to its adaptability for marine purposes. A general discussion followed.

NEW YORK, MAY 12

The local section of the Society in New York was entertained at its monthly meeting on May 12 with a very interesting address by H. DeB. Parsons on the Main Drainage and Sewage Disposal Plans for the City of New York. Mr. Parsons is a member of the Metropolitan Sewerage Commission of the City of New York and has been closely identified with this important work of developing a plan that will be applicable to this great and rapidly growing district. He showed by lantern slides how remarkably the city and environs have grown in the past 10 or 20 years and gave statistics on the enormous increases of population, the development of the city boroughs and the consequently increased quantities of sewage to be disposed of. To provide adequately for both present and future needs, plans had to be prepared that should be practical, applicable to the conditions and elastic to permit of extensions, and Mr. Parsons showed how by division of the entire city into drainage districts, it is proposed to accomplish this in a practical manner. He referred to each district and outlined the adopted plans in considerable detail. His talk was also extended to the main drainage works of Boston, London, Dublin, Glasgow, Paris, Berlin and Hamburg, to show how the plans for this district may be extended and developed as future growth of the city may require. The talk attracted a great deal of interest in view of the unusual engineering problems that are entailed in some of the districts, particularly that embracing the lower part of Manhattan Island which involves a 7-mile tunnel under Brooklyn and lower New York Bay to an outlet on a proposed artificial island in the bay.

CHICAGO, MAY 13

The concluding meeting of the season of the Chicago Section took the form of a banquet and social meeting held on May 13, 1914, at the Sherman House, Chicago. Paul P. Bird, chairman of the section, presided and acted as toastmaster. The meeting was primarily for the purpose of discussing the subject of Machine Shop and Machine Tool Practice. An informal reception was given to James Hartness, President, and Calvin W. Rice, Secretary of the Society, who came on from New York to attend the meeting.

The subject of the evening was presented by P. W. Gates, Robert W. Hunt and Arthur M. Houser.

Election of officers for the ensuing year followed.

BOSTON, MAY 13

A meeting of the Society was held in Boston on May 13, Boiler Room Practice being the topic of the evening.

Captain Charles H. Manning opened the subject with a paper on the assigned topic, in which he related his own interesting experiences and the changes which had developed during his more than fifty years work among boilers and fire rooms. He was followed by George H. Diman, who had had a similar long experience in boiler room practice, and who said that he believed the best results were dependent upon the good spirit which could be aroused among the workers.

W. G. Diman spoke on modern Boiler Room Operation and I. E. Moultrop on the boiler room practice in large electric power stations, prophesying the early adoption of larger boiler units than at present used, with a much greater overload capacity than is now common. James D. Andrew spoke on simple and rugged boiler house and equipment design, and believed that automatic boiler feed was possible with a good degree of safety. He recommended the use of CO_2 recorders and of weighing devices and said that firemen should be given proper instruments to show conditions in the fireroom.

E. G. Bailey spoke on regulating the air supply and on the importance of a draft gage, and F. W. Dean of the effect of good and poor firing as shown by tests.

John A. Stevens emphasized the importance of the investment item and Henry Bartlett described the probable application of stokers to large locomotives, too large to be handled by hand by one fireman.

CINCINNATI, MAY 21

A joint meeting of the Cincinnati Section and of the Engineers Club was held in Cincinnati on May 21. Henry M. Waite, manager of the City of Dayton, gave an address on Municipal Government under the City Manager Plan, in which he stated that the organization of the Dayton city government was based on the plan that had proved successful with large corporations. Five commissions were elected by popular vote, and the city manager was chosen by these commissions. This manager in turn selected five heads of departments, known as directors, for the five divisions, law, finance, safety, service and welfare. Mr. Waite had made his appointments, he said, irrespective of political affiliations of the appointee, and subordinates were selected by civil service examinations. This form of government placed the responsibility of good government and efficient service upon the manager and his directors, and if he was dishonest and inefficient, the manager might be recalled and his directors dismissed. Mr. Waite illustrated the great saving possible under this plan, citing specific cases. About twelve cities were now following this plan, he stated.

There was an attendance of about 150 and many questions were asked and answered by the speaker, arousing much interest.

BOSTON SYMPOSIUM ON SELECTIVE PACKAGE AND PNEUMATIC CONVEYORS

At a meeting in Boston on April 8, three papers were presented on Conveying Systems. One of these by W. O. Hildreth related to conveyors adapted for delivering packages or other materials from a central station, or from intermediate stations, to various other stations as selected by the sender at the time the goods are despatched. A second paper by F. B. Williams illustrated particularly the tube systems for transporting mail, for long distances underground. A third paper by S. L. Haines dealt with belt conveyors in use for handling magazines in publishing establishments and with link-belt elevators for packages.

CONVEYORS OF THE SELECTIVE TYPE

By W. O. Hildreth,[1] Boston, Mass.
Member of the Society

Selective conveyors are conveyors adapted for delivering packages or other materials from a central station, or from intermediate stations, to various other stations as selected by the sender at the time the goods are despatched. While this definition may not entirely eliminate the plain belt conveyor with the usual trippers for distribution of a continuous stream of material, this paper is confined to the consideration of conveyors for transporting separate packages to predetermined stations.

The delivery of these packages at the proper station may involve merely some device to sweep the package from a moving conveyor belt, or may involve the switching of some standard tray or "tote box" to a station located at the side of the conveyor, or may involve the construction of a carrier with individual cars adapted for delivering loads at any one of a number of stations located along the path of the conveyor.

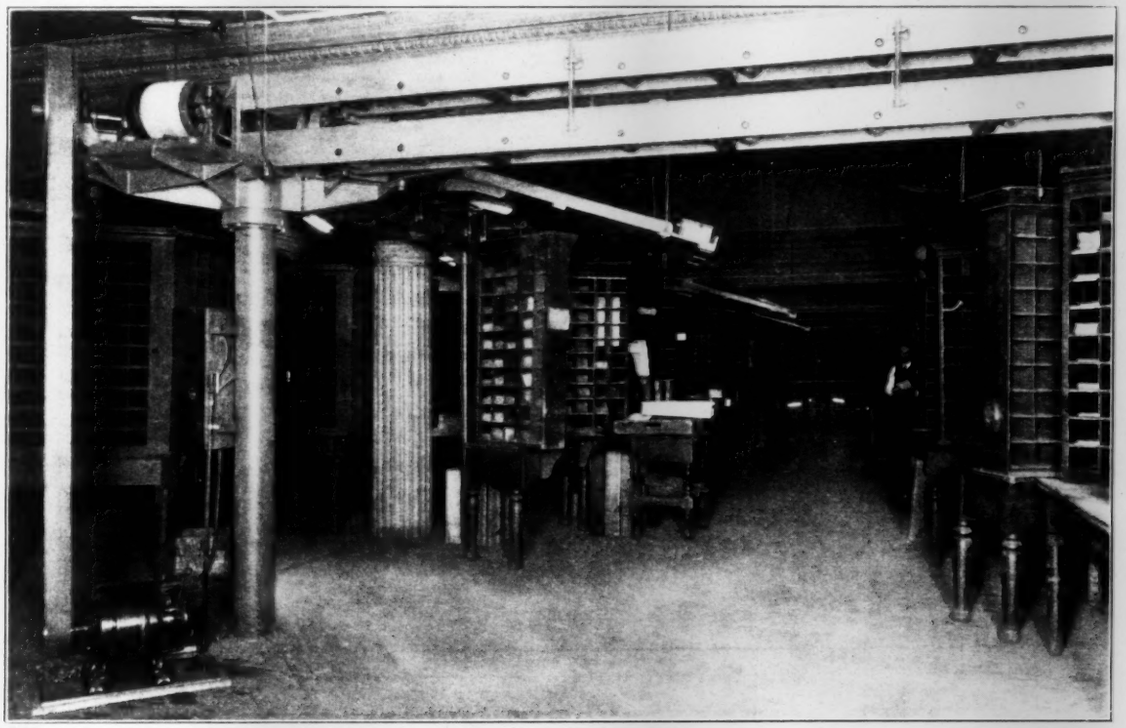

Fig. 1 A Tray Conveyor in use at the Philadelphia Post Office

Generally it is necessary to give service in both directions. With conveyors of the belt type this return service can be secured by the use of the lower or return part of the belt. With other types of carriers the conveyor may form a complete circuit so as to give

[1] Presented at the Boston local meeting of The American Society of Mechanical Engineers, April 8, 1914.

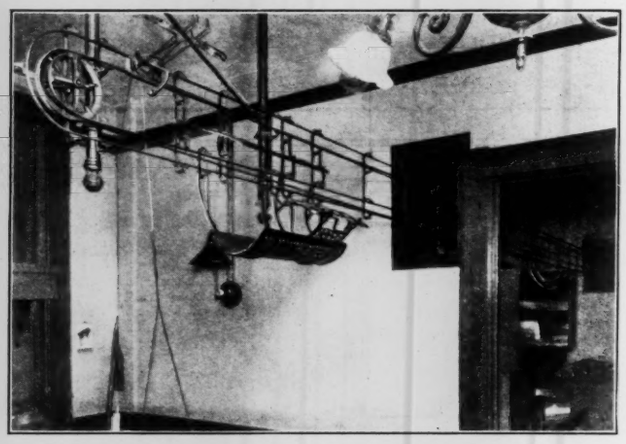

Fig. 2 View of a Typical Pick-up Carrier showing Details of a Station

intercommunicating service, although materials may always travel in the same direction.

While the belt conveyor type has a certain amount of flexibility in a vertical direction, it can make horizontal turns only by the use of another conveyor and these limitations compel the use of some more flexible means of connection between the individual cars or other transportation units, if we are to cover satisfactorily all the requirements of the modern manufacturing plant. Such selective conveyors must give practically continuous service between points located on several different floors, and must be able to avoid various obstructions and reach points that could not conveniently be reached by a belt conveyor.

One of the simplest methods for giving a series of separate deliveries to a number of separate stations located alongside a belt conveyor is to introduce a number of vertical stationary partitions above the moving belt so as to divide the conveyor into a series of divisions and then terminate these dividing plates successively at the various stations, at the same time leading the division plate to the edge of the belt so as to sweep off all material that is contained in this particular division.

Such a conveyor can be loaded at any intermediate point and the sender can determine the delivery point by placing his material in the proper division. It is evident that such a conveyor has all the limitations imposed by the use of a belt; nevertheless there is a considerable field of usefulness that can be served by such a device. It is well adapted for handling pass books in banks between tellers and bookkeepers, and for handling cards, order slips or papers that can be carried on edge between the division plates.

A modification of this carrier has been used in a number of telephone offices for conveying charge slips and toll line call slips. This modification retains the series of vertical division plates, but substitutes a smooth bottom plate for the moving belt. The tickets, which project above the division plates, are pushed forward by a horizontal finger attached to a car and driven by an endless cable. The car is guided on a track suspended above the division plates. It is possible, with this conveyor, to turn horizontal corners and to carry the slips from one floor to another by means of inclines which may be as steep as 45 degrees or more.

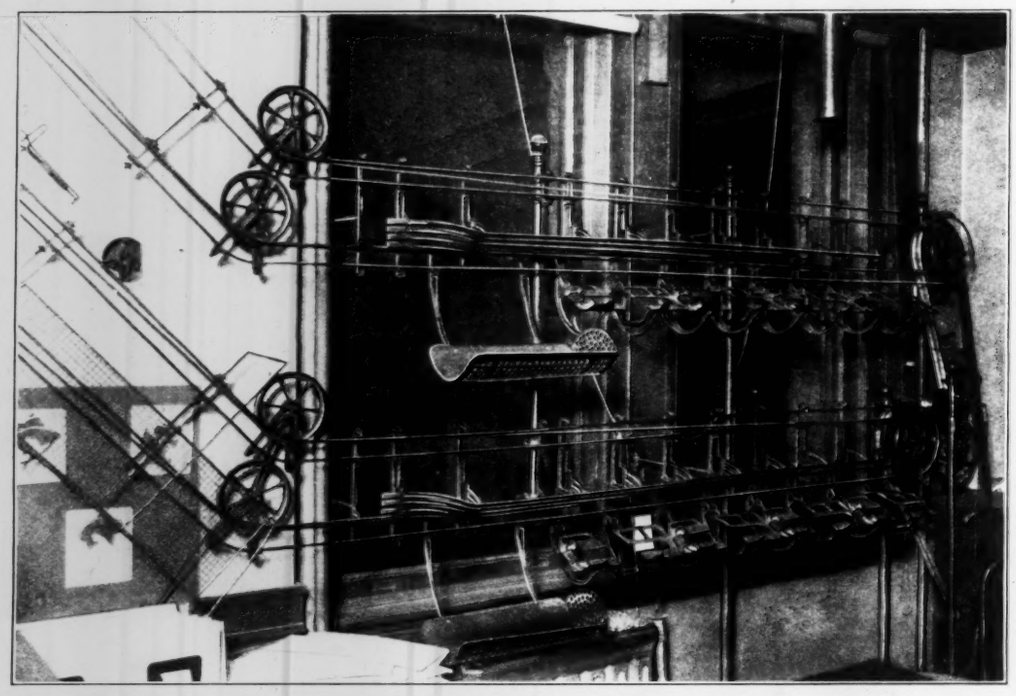

Fig. 3 View of Sending Station on a Pick-up Carrier System, showing Selective Mechanism for Four Stations

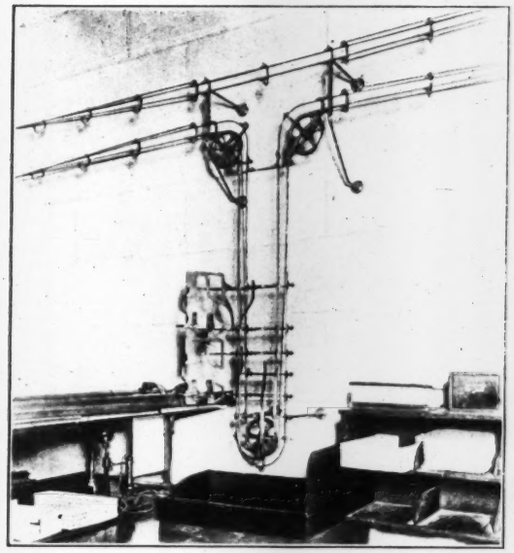

Fig. 4 A Vertical Sending Station on a Pick-up System, having Selective Mechanism for Two Stations

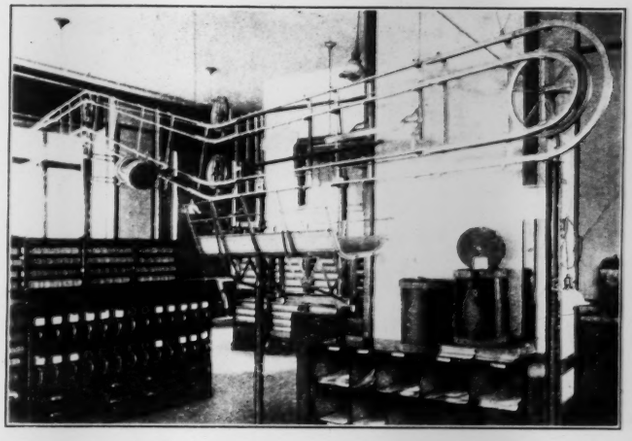

Fig. 5 A Pick-up System fitted with Large Cylindrical Carriers for Handling Large Envelopes and Bundles of Papers

This type of carrier with the moving belt has a considerable field for the distribution of materials that can be handled on a belt and swept from the belt at the delivering point.

Tray Conveyor.—The next step in the development of a selective conveyor, using a belt for the moveable conveying member, is what may be called a tray conveyor. The tray or tote box is in common use in manufacturing establishments for the transportation of small parts from one department to another. With this type of carrier the tray can occupy the entire width of the conveyor, thus cutting down the width of the permanent structure to a size just sufficient to accommodate one tray.

The carrying capacity of this type of conveyor is very large since there is a possibility of sending practically a continuous stream of trays and switching them to intermediate stations or to lines branching from the main trunk line of the conveyor at any point. The return service can be secured by the use of the returning portion of the belt and it is possible to send from any station on the line to any other station, thus giving intercommunicating service.

In this type of conveyor the tray is furnished with a moveable projecting finger, generally extending above the front end of the tray, and adapted for engagement with the switches which extend over the conveyor from the various stations. The selective finger on the tray is moved by the despatching operator to

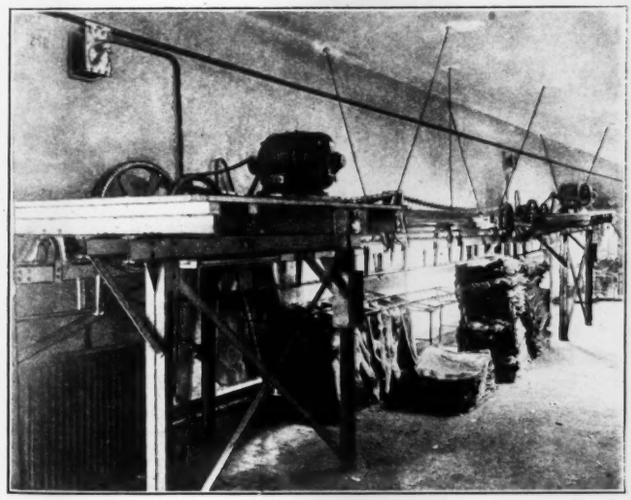

Fig. 7 The Driving Mechanism for the Bag Carrier System in the Chicago Post Office

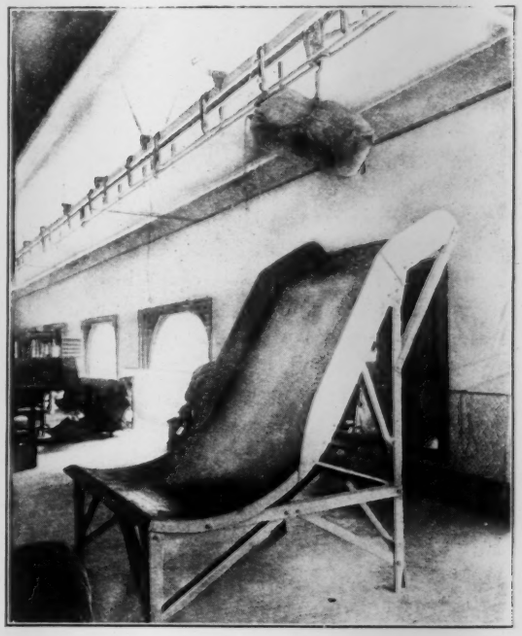

Fig. 6 View of a Bag Carrier System in the Chicago Post Office, with Receiving Chute

FIG. 8 VIEW OF A STATION ON A TYPICAL BOOK CARRIER SYSTEM AND A CAR ABOVE EN ROUTE

a numbered position corresponding to the station to which the tray is to be sent, and the tray is then placed upon the moving conveyor belt. The tray passes all the intervening switches until it reaches the station for which its selective finger is set, and after coming in contact with the switch it is deflected from the conveyor belt and delivered upon an inclined shelf, from which it is removed by the attendant.

Instead of switching to a station, the tray can if desired be switched to a branch line for delivery to stations located along this line. The width of the end of the tray, and the necessary spacing between successive positions of the selective finger on the tray, is the only thing that limits the number of stations possible on such a system. It is possible to cover more than one floor with one of these tray conveyors by transporting the trays on inclined conveyors from floor to floor, or by delivering the trays to automatic elevators, which in turn may deliver at any one of a number of different floors or to other belt conveyors with selective stations. A typical tray conveyor for Post Office work is shown in Fig. 1.

A further variation of this type of conveyor is made with a four-wheeled car propelled by an endless cable and running upon two rails. This car is provided with a cable gripping device that will disengage the car from the cable when the car is switched from the main line onto the switch track. The switch is operated by a selective finger on the car and the number of stations that can be used is limited only by the space available on the car for the selective switching positions.

A system of this kind, with automatic elevators onto which the cars are run and dropped several stories, has been in use many years in the Boston Public Library for transporting books from the stacks to the delivery desk. When cars are returned from the switch tracks to the main line, the moving cable is gripped automatically and the car proceeds until switched again from the main line at the station determined by the setting of the selective finger on the car.

While the capacity of this conveyor is not as great as the capacity of the tray conveyor, nevertheless it can handle a great amount of material with a very small expenditure for power. When cars are not actually en route, the power required for driving the cable is very small, the track is inconspicuous and does not obstruct the lighting of the shop at all.

PICK-UP CARRIER.—Another class of carriers that has been developed for the transportation of orders and correspondence, rather than for large quantities of manufactured material, is known as a "Pick-up Carrier" from the action of the car which actually picks up its load from a shelf upon which the load has been placed by the sender.

This carrier introduces a different principle of selection from those previously described, in that it has a series of cars permanently attached to an endless

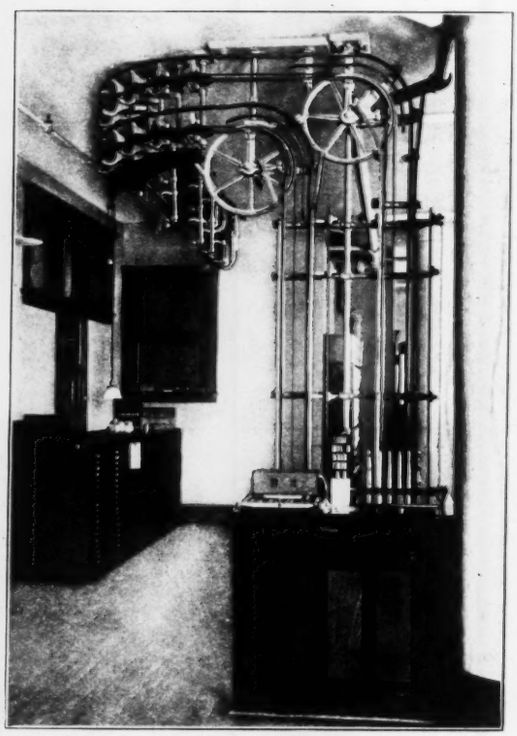

FIG. 10 DETAILS OF CONSTRUCTION OF VERTICAL AND HORIZONTAL TURNS IN A BOOK CARRIER SYSTEM

driving cable and sliding upon a pair of smooth round steel rods. The cars are furnished with gripping jaws of steel wire adapted for holding either flat envelopes or cylindrical carriers. The upper jaw is stationary, while the lower jaw is moveable and swings around a fulcrum pin with a spring to press the moveable jaw against the stationary jaw and hold firmly whatever material may be contained between the jaws. The moveable jaw has a projecting arm that rides upon a cam surface at the station so as to open the jaws for delivering the load and to allow the jaws to close again upon another load waiting upon the sending shelf. A typical pick-up carrier is shown in Fig. 2.

As the different cars have opening levers of different lengths, it is possible to have a series of cars, each one opening its jaws for delivering and picking up messages at two definite locations along the line. A message placed upon a certain sending shelf will be picked up by its own car only and will be delivered always at another definite location where the station cam is placed in the correct position to operate this particular car and no other one. A series of sending shelves at a station gives the sending operator an opportunity to send to as many destinations as he has shelves, and every car that arrives at his station must drop its message for him before picking up a message for the other station. In Fig. 3, is shown a sending station for two systems with four stations each.

In this carrier the selective mechanism is a permanent part of the car, itself, and does not require any adjustment by the operator or by the station mechanism. The only selective effort required of the operator is to select the proper shelf upon which to lay his message and the carrier does the rest.

In order to keep the size of the car and stations within reasonable limits, it has seemed desirable to limit the cam graduations on a station to five so that it is possible to send from a central station to five other stations and to receive messages from these five stations in return. It is practicable to handle papers or traffic envelopes as large as 10 in. x 13 in. with this system, or in cylindrical carriers as long as 30 in. In Fig. 5 is shown a system of this kind.

As the cars are traveling continuously, service is provided from each station at regular intervals and as the sender does not have to wait for a car, but has only to lay his message on the proper shelf and return to his work again, the service is prompt and regular without waste of the sender's time. The messages are dropped by the cars into a single receiving pan or basket at each station.

In cases where it is desirable to have intercommunicating service between a large number of stations, it is customary to group the central stations of a number of lines at one convenient point and make this point a clearing house for the entire system by transferring the messages sent in by the different lines to the proper shelf for transmission to their final destination. This

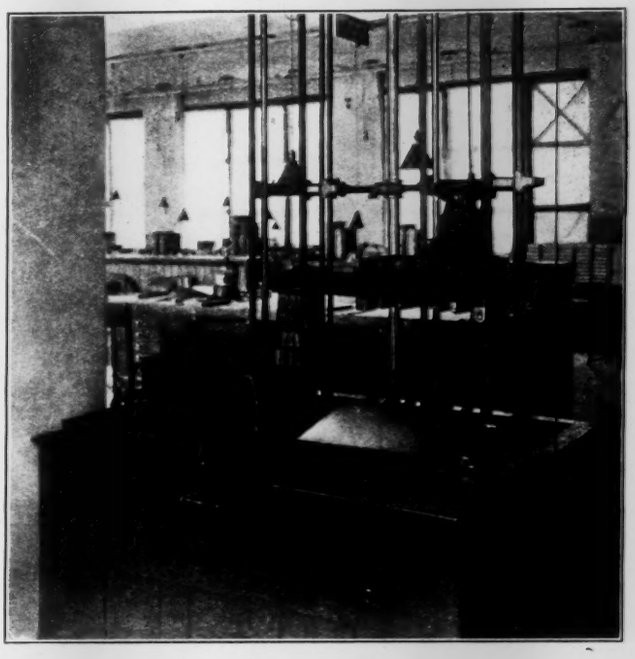

Fig. 9 A Station of Different Form on a Book Carrier System with Car approaching Receiving Fingers

work can usually be done by a filing clerk or some one permanently employed in the neighborhood of the station so that special help need not be employed for this particular purpose.

As this system is operated by a flexible cable, it is possible to turn corners in any direction so that stations on a number of floors can be served by a single line. The power consumption is small and the service is practically noiseless in operation.

Bag Carrier.—Another carrier with a capacity for handling loads as great as 150 to 200 lb. has been developed along somewhat similar lines, but with a different principle of selection. As this conveyor was first used for transporting post office mail in bags, it has become known as a "bag carrier." It consists of a series of two wheeled cars or trolleys permanently attached to an endless moving steel wire cable at frequent intervals often as close as 10 ft. apart. The car wheels run upon the lower flanges of structural steel channels with a pair of guiding rails below the channels to prevent excessive swinging of the cars. A system of this type is shown in Fig. 6.

Each car has a hook upon which the bags are hung and these hooks are hinged in such a way that they can be tripped so as to drop the loads hung upon them. A moveable unlocking slide is arranged upon the car so that a selective finger on the car can be set at the sending station in as many different locations as there are delivery points on the line. This selective setting is done at the sending station as the car passes an inclined cam device whose position is controlled by the operator. This cam moves the unlocking slide and the

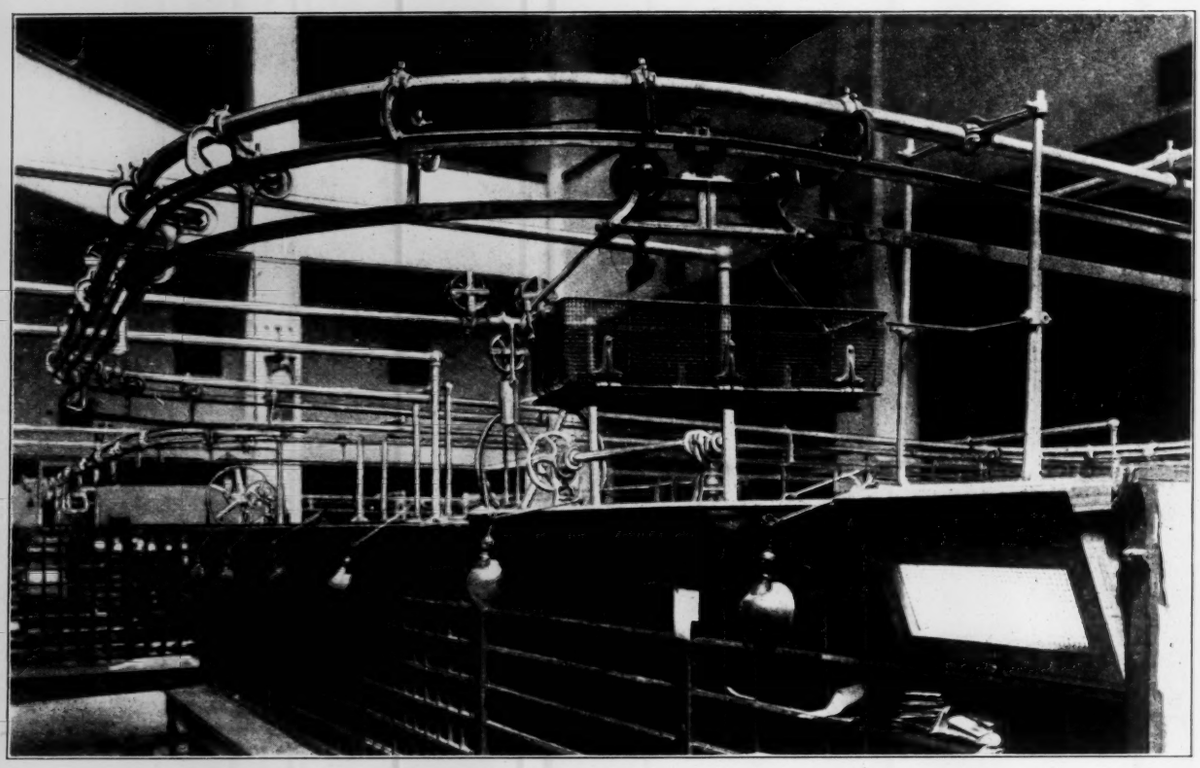

Fig. 11 View of Sweep-off Carrier System in the Chicago Post Office

selective finger to a position corresponding to the delivery station desired.

Each delivery station has a tripping finger permanently fixed at a different height from all the other stations and arranged so as to trip the car hook on every car that passes having its selective finger at the proper height to engage with it. The bags, when dropped from the cars, are received on suitable chutes from which they slide to the floor or to tables. Just before the cars complete their circuit and reach the sending station again they pass a resetting cam, which returns the selective finger to the neutral position, ready to be set again at the sending station.

As the cars are permanently attached to the driving cable, a rather novel cable drive has been devised, giving a powerful pull and operating on a straight portion of the cable without requiring the introduction of grooved driving sheaves. In this driving device the cable is driven by a series of gripping jaws in pairs attached to an endless chain moving parallel to the cable, and driven by sprocket wheels. Each pair of jaws is connected by springs, thus giving a uniform pressure on the cable.

At the point when the jaws begin to leave the cable at the driving sprocket, a cam is located so as to open the gripping jaws and allow them to leave the cable and pass around the sprocket wheel and return again to the point of commencement, where another cam opens the jaws so as to allow them to grip the cable again. This device makes a very satisfactory arrangement, as it can be placed at any point of the line where there is a straight section of cable. The cars pass this drive without any trouble, and it does not require the addition of a number of driving sheave pulleys around which all of the cars would have to pass. With lines of any considerable length, it would not be possible to get sufficient driving power from a single-grooved driving sheave with 180 deg. arc of contact, and several driven sheaves around which the cable and the attached cars must pass in succession would introduce several objectionable complications.

Book Carrier.—Among the carriers with individual cars, each car having its moveable selective finger, the most interesting perhaps is the so-called Factory Service Carrier. This was originally developed for transporting books in large libraries between stations located in the book stacks and the delivery desk, but it proved to be very well adapted for distributing small manufactured parts and tools from one part of a factory to another.

The cars are permanently attached to a wire cable at intervals depending upon the amount of traffic to be accommodated. The track upon which the car wheels run is of ¾ in. round cold rolled steel and the cars are of the finger bottom type so that the car can pick up its load or drop its load by passing between a similar set of fingers forming the stations. A system of this type is shown in Fig. 8 with car en route.

The car body is mounted upon a truck and arranged to swivel so as to keep the car body in a horizontal

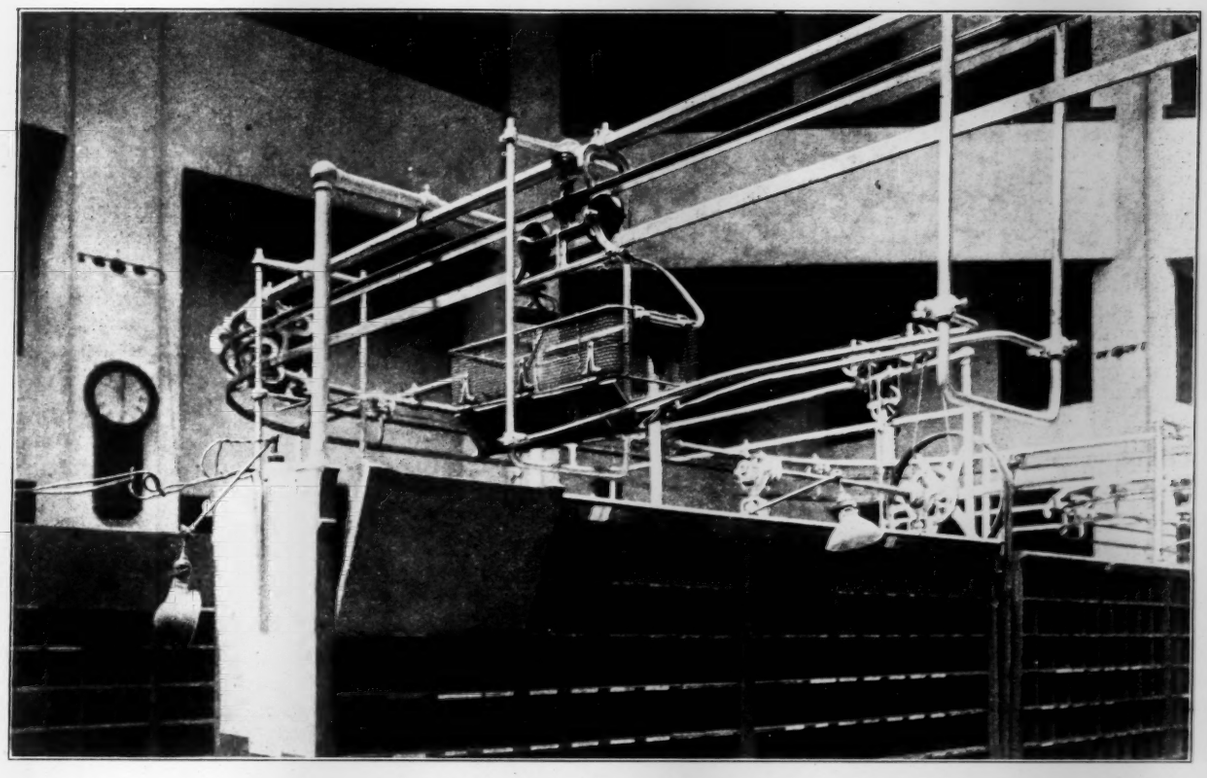

Fig. 12 A Sweep-off Carrier just Leaving a Station and Closing Bottom Doors

position when the car is traveling on vertical track as well as when the track is horizontal. This type of carrier can pass from floor to floor vertically and can make horizontal turns at any angle so as to reach any required position or avoid obstructions, as shown in Fig. 10.

In this system we have again the moveable selective finger upon the car to determine, by its position, the station at which the car will deliver its load; and this selective finger is moved by mechanism at the loading station under control of the operator. The cars in all cases pick up their loads when passing upward through the sending station fingers and drop their loads upon the receiving station fingers when passing downward through these station fingers.

As the cars are continually passing the sending stations, it is obvious that the loaded sending station fingers must be kept out of the path of loaded cars but must be advanced into the path of the first approaching empty car so that the load can be picked up and carried to its proper destination.

To carry out this condition, the sending station fingers are mounted upon a wheeled truck operating upon horizontal rails. This finger truck is normally held back by a weight working within a dash pot tube. When the operator has placed a load upon the sending fingers he moves a lever to a numbered position corresponding to the station to which the load is to be sent and then depresses a lever, which compresses a spring and stores up sufficient energy to move the sending fingers forward when the next empty car arrives.

Upon the approach of an empty car the catch holding the station fingers back will be tripped and the fingers with their load will move forward into the path of the car. The car then picks up the load and while passing the station has its selective finger moved to the position corresponding to the delivery station. After the car has left the sending station, the catch holding the station in forward position is unlocked by the car and the sending fingers are drawn back by the counterweight out of the path of succeeding cars.

While the loading fingers are held back, awaiting the approach of an empty car, a loaded car will not trip the station catch because this catch is tripped by a lever arm on the car having two positions, one for an empty car and one for a loaded car, and the lever when in the loaded car position will not unlock the station catch. The receiving station fingers are hinged at the back end so that they are normally swung up out of the way of passing cars, but an approaching loaded car, with its selective finger set for a station, will operate a lever and throw down the station fingers so as to remove the load from the car.

As these station fingers drop only to an inclination of about 20 deg., the load will slide down and away from the fingers to an inclined shelf, from which the

loads can be removed by hand. After the car has passed down below the receiving station it operates a lever that swings the receiving station fingers up and out of the way of succeeding cars until the approach of another car, which has its selective finger set for this station.

This type of carrier is driven either by a grooved sheave wheel or, for a long line, by a grip chain drive as described for the bag carrier. This carrier has been developed with a car as large as 12 in. x 17 in. to take loads of 15 to 20 lb., and these loads are generally handled in flat trays or baskets unless the loads consist of letters or papers that can be handled in envelopes or file wrappers.

Sweep-off Carrier.—Another type of carrier known as a Sweep-off Carrier has been developed more especially as a collecting carrier for collecting letters, orders, or other papers from a considerable number of stations and delivering them to a limited number of receiving stations located somewhere on the circuit of the line.

In this conveyor the load is carried in a basket supported from a two-wheeled car running on a single rail with guide rails below to keep the basket from swaying. The material to be sent is laid upon a horizontal shelf located just above the path of the basket and this material is swept into the basket by a brush attached to the car and moving with it. A considerable number of stations, therefore, can be served by a single car.

The basket of this carrier has a hinged bottom and will drop its load into a hopper when the car bottom is unlocked at the delivery station. It is possible to make this carrier selective by furnishing a number of separate shelves at the several sending stations. The shelves in this case are normally below the path of the car and are brought up to the sweep-off position when the proper car arrives and trips the holding down catch.

The cars are provided with permanent selective devices, which are operated by the receiving stations so as to trip the car doors on the basket when it arrives at its own station, but which are arranged to pass all the other cars which deliver at other stations. This type of carrier has been used very largely in Post Offices to handle misdirected letters from the various sorting cases to some central point where proper addresses can be supplied or where illegible addresses can be deciphered.

Promptness in handling such letters will generally prevent the letters from being held over to the next delivery and sometimes will prevent them from being held over to the next day. In large Post Offices this type of carrier is often used to collect the Special Delivery letters from the facing tables and from the opening tables where the railroad mail is received and to carry these specials to the special delivery division.

PNEUMATIC CONVEYORS

By F. B. Williams, Boston, Mass.

Member of the Society

The first successful pneumatic tube system was put in operation previous to 1858 in London, England, with a 1½ in. tube 650 ft. long. In 1858, this was extended with 2½ in. tubes. From then on the system has grown rapidly and London has now many miles of despatch tubes. The usefulness of this system has also been extended in the large cities of England and Germany. The transmission of telegraph messages by pneumatic tubes commenced in 1865. Also it was at about this time that pneumatic tubes were first used for transmission purposes in this country, John Wanamaker's store in Philadelphia having probably had the first installation.

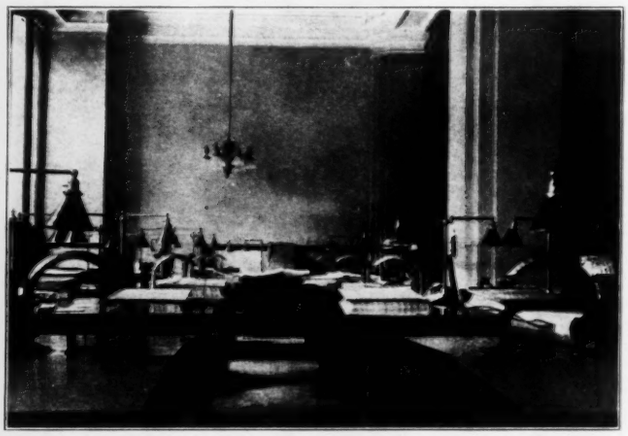

Fig. 1 View in a Modern Office with Pneumatic Tube Connection to Each Desk

There are three systems in general use, known as the vacuum, the pressure, and the vacuum-pressure systems. Each of these has very distinct advantages when considered from the standpoint of the service required and other determining conditions.

The vacuum system in its simplest form, omitting the power plant, consists of two stations, one called the central station and the other the out-station. As seen at the central station there is a sending and a receiving tube and these two tubes extend to the out-station. The receiving tube at the central station is connected to the suction drum, and as the two tubes are connected at the out-station, they form one air circuit.

A carrier placed in the sending tube at the central station is sucked to the out-station and there discharged by means of a suitable terminal. The air is there by-passed to the other tube, in which it returns to the central station and is drawn into the suction drum. A carrier placed in what is the sending tube at the out-station is sucked to the central desk and

there discharged, while the air is by-passed to the suction drum. In this way communication between the two stations is continuous; that is, carriers can be sent from each station to the other at the same instant—a very desirable feature where the service is heavy, as in a department store.

Vacuum terminals are simpler than the terminals for other systems and the method of operation by exhausting the air is more economical so far as the expenditure of power is concerned. But the working pressure is limited to something less than 14 lb. and there might be conditions which would make that insufficient.

The pressure system is just the reverse of the vacuum system, the carriers being pushed or forced by pressure instead of being sucked or pulled to their destination. Of course, theoretically, the operation of the two systems is similar in that the carriers are propelled by the greater pressure behind than in front of them. In the vacuum system the power is applied in front of the carrier, but in the pressure system it is applied behind the carrier.

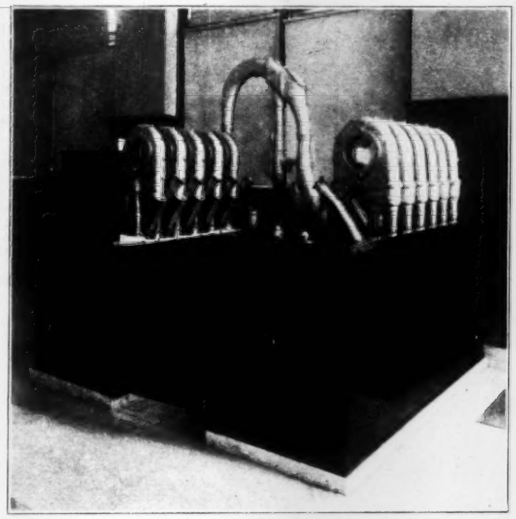

Fig. 2 A Terminal for a Vacuum-Pressure Tube System

Pressure systems are used in carrying the U. S. mail in many of the larger cities in this country and two of the several reasons why pressure is used instead of vacuum, are first, that with the pressure system, small leaks are not objectionable save that they are a direct loss of power, while with the vacuum system, a leak underground would be disastrous to the working of the system and also the possible entrance of moisture might cause damage to the contents of the carriers; second, in case of a carrier being blocked in the tube, the pressure can be reversed and raised and the carrier often blown out, while with the vacuum system the greatest vacuum possible might be entirely inadequate for this purpose.

Pneumatic tubes on the pressure system now provide direct connection to 46 United States Post Offices, which offices, according to the most recent Post Office statistics, serve a dependent population of 5,881,000 people. In these pneumatic tube Post Offices are employed 6,120 clerks and 3,131 letter carriers, and through the tubes are weekly carried 137,295,000 pieces of mail matter. Mail for Post Offices beyond the pneumatic tube districts is also carried as far as possible by tubes and then transferred to wagons. These statistics do not include the City of Philadelphia or the Brooklyn General Post Office. Each one of these Post Offices, because of its pneumatic tube connection, gives to its surrounding population the same service that is given from the main office of its city. In other words, the pneumatic tubes, since they are practically instantaneous, make the sub-stations with which they are connected a part of the main office of the city. It is interesting to note that, assuming the above amount of mail matter to be carried by the tubes for 52 weeks a year, the cost of carrying by pneumatic tubes is at the rate of ninety-two pieces mail matter for one cent, or approximately fifty-four cents per hundred pounds.

The vacuum-pressure system is used where the service is lighter. In this system the carriers are drawn to the central station by vacuum and blown back to the out-stations by pressure.

Here might be mentioned the single-tube pressure system of the Lamson-Miles type, which has but one tube between the two points to be connected. This tube is fitted with a combined despatching and receiving terminal at each end, and the compressed air is carried by small iron pipes to the terminals at the ends of the tubes. A compressor and storage tanks supply and maintain the power for operating the tubes. When idle the tubes are normally open to the atmosphere and are often used as speaking tubes. The use of a single tube saves room in passageways and walls of buildings, frequently a matter of great importance.

When a carrier is to be transmitted, air pressure is introduced into the tube behind the carrier from the storage tanks, in which pressure is maintained by an automatic regulator, that controls the starting and stopping of the compressor. The compressor automatically starts when the pressure drops below a certain point and stops when it has produced the normal working pressure of the system. The air supply pipe is much smaller in area than the transit tube and consequently while the carrier is on its course the air under pressure from the supply pipe expands in the tube. Hence if a carrier tends to foul in a bend or other part of the tube, it offers a resistance and the air pressure behind it immediately makes up to the pressure carried in the supply pipes and thus the carrier is automatically relieved and pushed along.

A combined receiving and despatching terminal is attached to the ends of each tube, and to these terminals are also connected the supply pipes so that

the air pressure can be admitted to the tube at each end and carriers can, therefore, be despatched alternately from either end of the same tube. As a transmission takes but a few seconds, no practical inconvenience is experienced by using one tube for transmission in opposite directions. In answer to the question as to what will prevent carriers from being despatched from both ends of a tube at the same time, it should be stated that this does not happen because the tube is normally open at both ends and when a carrier starts from one end, the free air in the tube is forced ahead of the carrier and out at the other end; thus a carrier cannot be inserted at what is temporarily the receiving end until the traveling carrier is expelled, because the outward rush of air makes it impossible.

The operation of the combined receiving and despatching terminal is as follows: After a carrier has been inserted for transmission, a gate or cover normally open, is closed behind it, which closing of the cover automatically locks it in place and at the same time opens an air valve, permitting an inrush of compressed air behind the carrier. The compressed air expands and pushes the carrier at increasing speed to the discharge end of the tube, where it is deflected by a chute into a suitable receptacle. A simple device cuts off the air pressure at the despatching end, and at the same time the closed gate or cover at the sending end is unlocked and the tube is again thrown open to the atmosphere. All these operations are accomplished by the back pressure of the air behind the carrier in transit without the use of electric or other connections.

The tubes used for the transmission of carriers are of kalameined steel, brass, or aluminum. The sizes mostly in use are 2¼ in. and 3 in. outside diameter. Also 4 in. tubes and 3 by 6 in. oval tubes are largely used where the material to be transmitted is bulkier. The bends are made of brass, and are formed by cutting to a length according to the radius of bend desired, filling with water and while under hydraulic pressure, bending around a form; the operation takes but a very few moments and a perfect bend is formed, with the section absolutely circular.

Positive rotary blowers are used in the majority of the plants installed. This type can be used either as a pressure blower or as an exhauster, and is more economical than a compressor when operating against pressures less than 7 lb. per sq. in. The style of blower used consists of a casing in which two impellers revolve in opposite directions, each impeller being of a double lobe section symmetrical with its shaft and the two impellers so set that the lobe of one fits into the recess of the other. The impellers work as close as possible to the casing so as to prevent loss through leakage, and to keep them at their proper relative speeds, one shaft is driven by the other through a pair of gears. If the system is of the vacuum type the inlet side of the blower is connected to the galvanized iron suction drum in the central station, if of the pressure type, the outlet side is piped to the central station, and if of the vacuum-pressure type, both inlet and outlet are piped

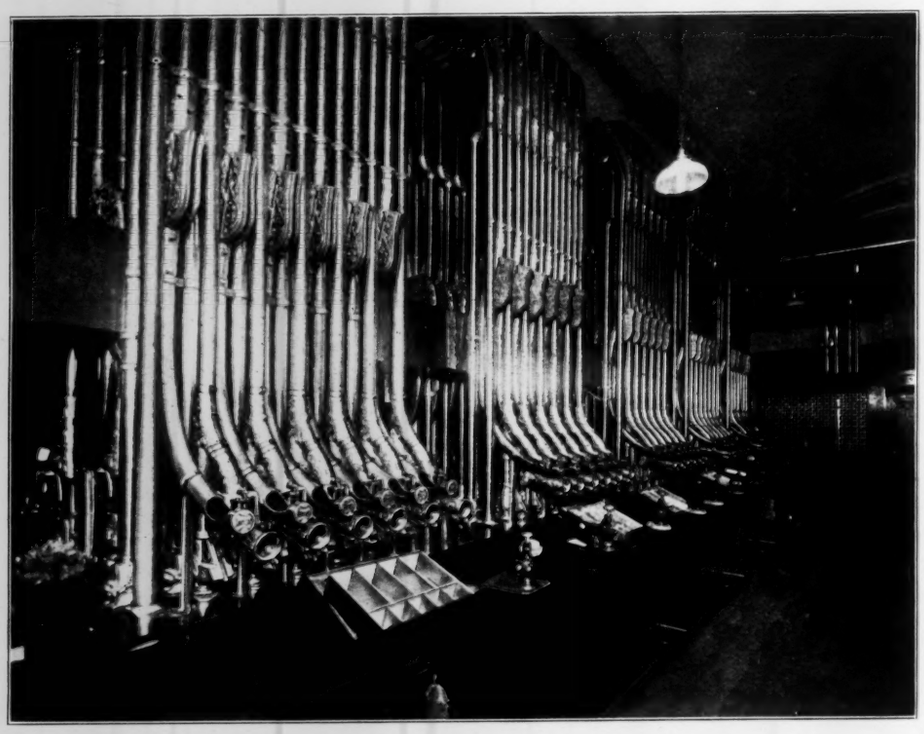

Fig. 3 A Large Central Desk for a Department Store System

to separate drums in the central station. The blowers are usually driven by electric motors, although occasionally they are directly connected to steam engines.

With many of the vacuum and pressure systems a power saving device is used, as in a system of, say 40 out-stations, it is safe to say that the greatest number that might be in use at one time is 28, and power must be supplied for 28 lines. Ordinarily but 4 or 5 are in constant use. By using a variable speed motor, of say four to one range, the blower can be made to supply power for, at its lowest speed, 3 lines, but as demands for more service are made from time to time during the day the motor will speed up until the maximum of 28 is being taken care of.

When the power control system is used on vacuum lines, a vacuum of, for instance, 16 oz. is maintained

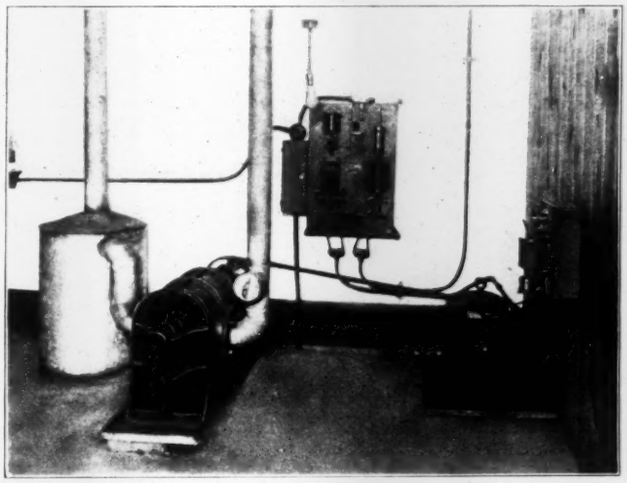

Fig. 4 View of a Blower Plant for a Small System, showing Automatic Control Board and Muffler

in the suction drum at all times irrespective of the number of lines in service. This constant vacuum is maintained by connecting the suction drum to the upper part of a cylinder in which is a weighted piston, that remains balanced and stationary as long as the vacuum above it equals 16 oz.; but should the vacuum drop, by opening of a tube for the transmission of a carrier, the piston slowly drops and at the same time turns the field rheostat of the motor so as to speed the blower up to maintain the 16 oz. vacuum. Should a greater vacuum momentarily exist a relief valve operates to reduce it to the proper point.

When the vacuum in any one of the lines is broken by the insertion of a carrier, a device at the end of each air circuit, called a power control device, automatically keeps the line open long enough for the carrier to reach its destination and then "times off," and the line comes to rest and so remains until the next carrier is inserted. It is not necessary to wait until one carrier has reached its destination before inserting the next; the vacuum in the line will take care of several carriers, and, except in the case of a very long line, it would be almost an impossibility to overload an air circuit because the carriers travel at such a high rate of speed that they would begin to deliver at the other end before the critical load was reached. And as in actual practice, the carriers must be loaded with letters, messages or cash, there must be an appreciable interval of time between each transmission of a carrier, and this prevents any one line from being overloaded. This power-saving device is of the vented cylinder and piston type and is very flexible as it can be adjusted for varying lengths of lines. It can be set to "time" anywhere from 1½ seconds to 2 minutes to accommodate any length of line.

From an engineering stand-point, the best system is one that uses power only when a carrier is in transit and is known as the start and timing-stop system. This system is operated by means of a special switchboard, on which an electric circuit is closed by the insertion of a carrier in the terminal for transmission, and that throws in the main power circuit, causing the motor-blower unit to automatically start up and supply the necessary vacuum or pressure, as the case may be, and it does not stop until the carrier reaches its destination. If several carriers are sent, even from remote parts of the system, the power is supplied until the last carrier is delivered.

The latest improvement is the "power-saving start and timing-stop system," which is similar to the previous system, but goes one step farther and supplies power according to the number of lines in service. If one is used, power for one is supplied; if half a dozen, the power unit speeds up to supply the proper power for those six lines and then comes to a stop when the last carrier is delivered. This is as it should be; in all but the largest systems, there are a great many times when no carriers are in transit, and then there are times when there may be several, possibly up to the capacity of the system, dispatched at almost the same time. This system uses only as much power as is required to transmit the carriers and shows a very great saving over all other systems.

The terminals used are of brass and bronze construction, except in some of the largest sizes where iron is occasionally used. Most of the terminals used on the larger vacuum tubes are of the double-door type, in which the carrier passes through two valves before it delivers. This for two reasons: One is that the noise is eliminated, and the other is that the momentum of the carrier is lessened. When a carrier passes from the tube into the terminal it passes through the first valve into a chamber where the air pressure is slightly below atmospheric; its momentum, checked by its passage through the first valve, carries it through the second valve into the atmosphere and to the receiving basket. The noise of the vacuum terminals was one of the principal objections to that system as applied to

large tubes, but since the double-door terminal has been perfected there is no annoyance on that score.

The carriers are of leather except those used in department stores, which are of metal with felt heads. The leather carriers are made in various lengths with hard felt heads and are of both closed and open types. The lengths of carriers are determined by two factors, the requirements of the service and the radius of the bends. A carrier 8 in. long, for a 3 in. pneumatic tube, requires bends of 2½ ft. radius, and a carrier 10 in. long requires bends of 3½ ft. radius.

It is often a serious undertaking to lay out the tubes and bends for long carriers so that they will not be unsightly or interfere with the design of the building in which they are located. The modern office building has usually a chase or riser flue that is available for the risers to the various floors, but in some of the reinforced concrete buildings and those of the mushroom type of construction, the difficulties of installation are numerous.

Pneumatic tube systems are used principally for the transmission of cash, mail, or messages of an interdepartmental character. Occasionally they are used for the carrying of other material, as in the Winchester works in New Haven, where powder is delivered to the loading machines by pneumatic tubes. The Eastman Kodak Company has an extensive system of tubes which perform a service that would be almost impossible to duplicate by any other means. Their stocks of films, plates and bromide and other papers are kept in rooms dimly illuminated by means of specially colored electric lights, and these rooms are so dark that a person going in from the outside would be almost helpless. The pneumatic tube service is effective in these rooms, whereas it is easy to see that a messenger service would be not only very slow in comparison, but very greatly handicapped on account of the illumination.

One of the essential routine requirements of a factory, large or small, is an equipment for handling mail, instructions, orders, and blueprints rapidly. Unless the method of distributing the mail is effective, delays and confusion always result. This is particularly true in the big factories where often more mail is handled daily than passes through many a small city post office. But the methods adopted by these large establishments are applicable as well in the small plant, for the complete system for handling the mail is generally built up of several units, any one of which can be advantageously adopted in the smaller factory. Those reasons of economy which bring refinement in the large plant are just as effective in the smaller establishment where their importance is often overlooked. Pneumatic tubes bring remote buildings side by side for business purposes.

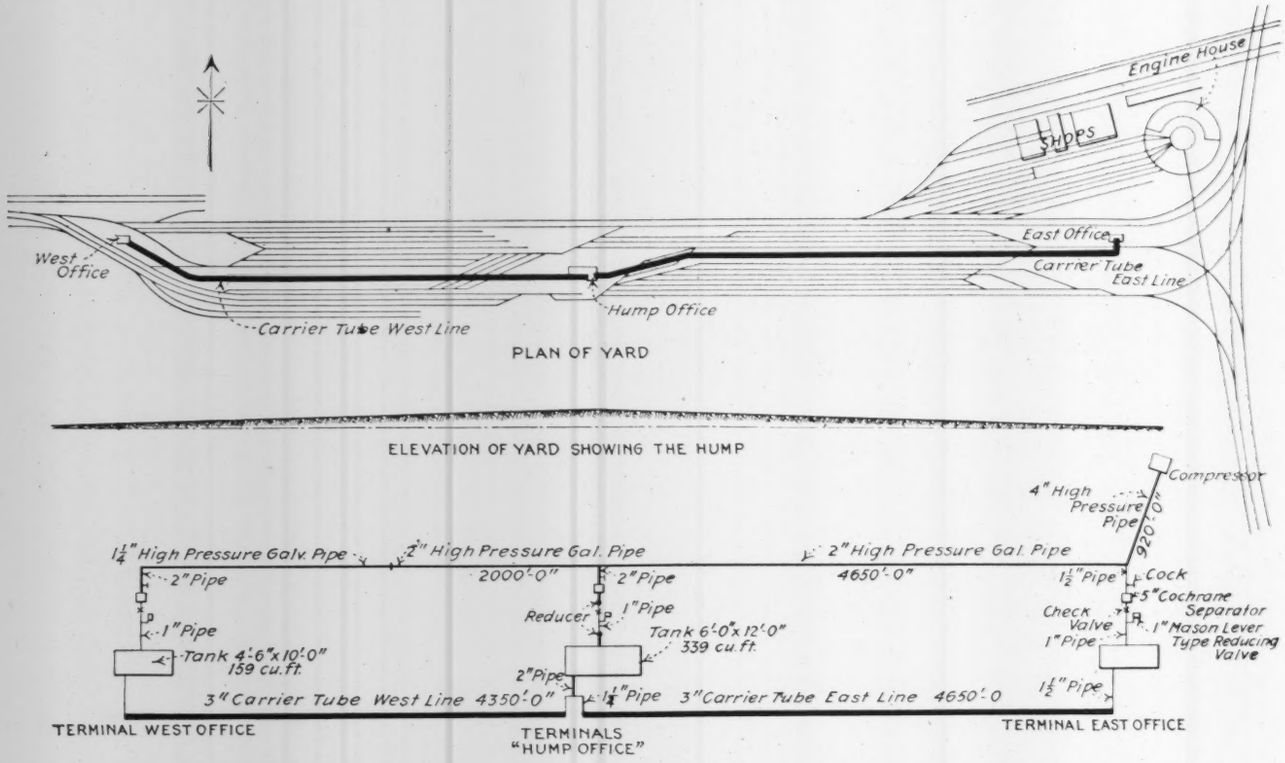

FIG. 5 ARRANGEMENT OF THE "HUMP" FREIGHT YARD LAYOUT AND DETAILS OF TUBE SYSTEM

An interesting industrial application of pneumatic dispatch tubes has recently been made to a modern "hump yard" freight terminal which due to the peculiar governing conditions, has resulted in an unusual economy. The saving due to this installation, at a total

investment of less than $10,000, amounts to an actual cash saving of at least $500 per day, while at the same time an increased efficiency of service is gained, the value of which is incalculable but of utmost importance (Figs. 5 and 6).

This yard is located at Gibson (near Hammond), Indiana, 23 miles southeast of Chicago on the Chicago, Indiana & Southern Railroad, being the Chicago freight terminal of the New York Central lines. The function of this yard is to facilitate the distribution of cars from incoming trains for prompt delivery to connecting roads, and conversely, to assemble into outgoing trains the cars received for forwarding. This

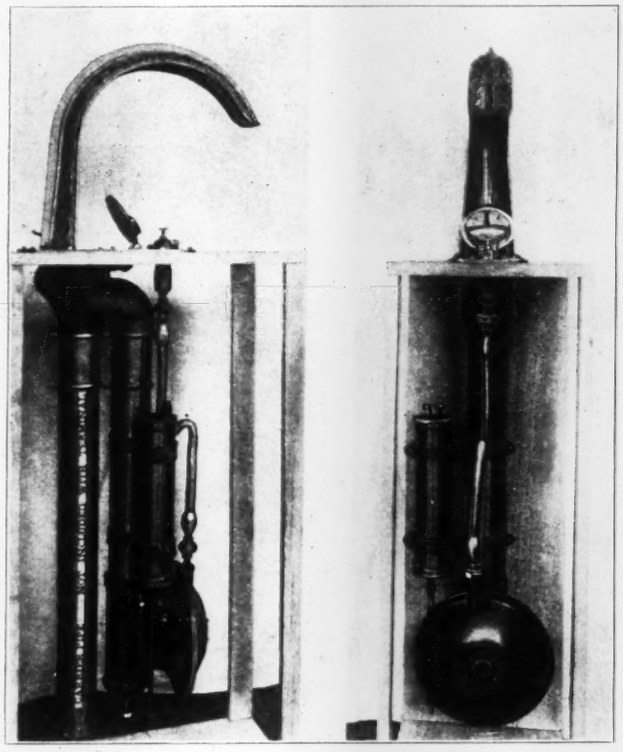

Fig. 6 Terminal used on the "Hump" Yard System

is accomplished in the following manner: The yard is laid out as an East yard and a West yard, each practically a duplicate of the other, and consisting of series of adjoining tracks with connecting ladder tracks at both ends. These lead respectively east and west from an artificial elevation in the level of the yard between them, and a car upon being pushed up this elevation by a locomotive will, after getting over the peak or highest point, run down on the other side by gravity where it may be switched from the ladder track into the yard tracks at will.

To illustrate, assume an incoming train to consist of 50 cars destined for, say, 20 different connections, the first two for A, the next one for B, the next three for C, the next two for A, and so on; the engine which has brought the train in is disconnected therefrom and a switch engine pushes it up the hump until the first two cars pass over the peak of the grade and run down on the other side, where they are switched say to track No. 1, followed immediately by the third car, which is switched to track No. 2, this in turn by the next three cars, which together are switched to track No. 3, the next two cars to track No. 1, and so on till all cars in the train have been distributed and thus reassembled directly into new trains with practically a continuous and uninterrupted movement of cars in the same direction all the time.

The incoming train brings the forwarding instructions from which orders covering proper distribution of cars are made out by the clerical force at the main yard office adjoining the Hump. In order therefore to insure quick handling of trains, it becomes imperative to have forwarding instructions delivered to the office and the orders in turn delivered to the train and yard crews in the shortest possible time. This is done through the Yardmaster's offices, each of which is nearly a mile from the main "Hump" office in opposite directions, and as the movement of trains is directly dependent upon these orders, it follows that any delay in the transmission means an equal delay in the despatching of trains, with a direct loss of an amount equal to cost of train crews. Hence the importance of the time element is at once apparent, but the extent of its importance will be better appreciated when it is understood that the railroad management figures the cost of a train crew at $5 per hour and that a total of from 150 to 200 trains are handled at this yard every 24 hours. Messenger boys were formerly used, and even at best the time for transmission was very considerable owing to the distance to be covered, the character of roadway and the natural unreliability of such service, while in inclement weather the business was well nigh paralyzed.

Since the installation of the pneumatic tube system by use of which it takes less than three minutes to convey messages between the Yardmaster's offices and the "Hump" office, and which have proven reliable in all kinds of weather, there has been saved one-half hour to an hour (an average of ¾ hr.) in the time of each train crew from which the direct money saving figures out as follows:

Cost of train crew, ¾ hr. @ $5 per hour.	$3.75
Trains despatched in 24 hrs. (150 to 200, or a mean of 175).....	175 Trains
Hence direct money saving per 24 hrs. is 5 (dollars) x ¾ (hour) x 175 (trains per day) equals $656.25...	$656.25

Thus the figure of $500 per day, as given above, is a very conservative statement.

The system is of the straight high pressure pneumatic type, with diaphragm latch terminal and supplementary time-off device, there being two single lines of 3 in. kalameined steel tubing, one running from the "Hump" office to the East Yardmaster's office, a

distance of 4650 ft., and the other running from the "Hump" office to West Yardmaster's office, a distance of 4350 ft. The tubing is laid from 3 to 4 ft. underground (frost line is about 4½ ft. down), joints being made with sleeves of a rust-proof composition called "Toncan Metal," and the whole is heavily coated with asphaltum paint. The terminals are of the up-discharge type with vent-actuated pressure timing valve and special long timing control.

Both ends of the tubes are alike and are normally open, with no air flowing. In sending, a carrier is inserted in a terminal, the clapper closed and air then admitted behind the carrier by pressing a button, which actuates the automatic control device, by which air is delivered from a low pressure storage tank for a pre-determined period, sufficient to insure arrival of carrier at other end of tube. Air is supplied to the storage tanks from the regular railroad service for operating switches, signals, etc., at a pressure of 90 to 110 lb. at the compressor. This is located in a shop some 950 ft. from East Yardmaster's office and there is a loss in pressure of about 20 lb. in transmission. There are three storage tanks, one at the East Yardmaster's office, one at the Hump office and the third at West Yardmaster's office. The air is brought underground from the compressor to the East tank, with branches to the Hump and West tanks, to each of which it is connected through a 5 in. Cochrane oil and water separator, a 1 in. check valve and a 1 in. Mason lever type reducing valve, that keeps the air at 11 to 15 lb. pressure in the tank, depending upon conditions. A 1½ in. or 1¼ in. pipe leads from the tank to the pressure timing valve on the 3 in. carrier tube, in each case giving a pressure in the tube behind the carrier of from 6 to 10 lb. The tank at the Hump office, about 5570 ft. from compressor, is supplied by 4650 ft. of 2-in. iron pipe, and connection to the tank is made in the order named through a 2-in. cock, a 5-in. Cochrane oil and water separator, a 1-in. check valve, a 1-in. mason lever type reducing valve, and a 2-in. pipe. The pressures are approximately the same as on the East tank.

No extra help is employed in connection with the tube system, the carriers being handled by the clerks, who make out the orders. The total number of carriers transmitted over the whole system for the 24 hours ending at 1 p.m., May 17, 1913, was by actual count 220, which is said to be about half the normal average during the busy winter season. The cost of maintenance, including all labor and material for the entire system of tubes, supply pipes, etc., for the three months of January, February and March, 1913, amounted to $17.92, which included an abnormal expense for clearing out the high pressure supply pipes, necessitated by their having been frozen. (It will be noted above that the pipes were not laid below frost line.) This monthly average of $5.97 is therefore high and a more nearly correct figure would be about $3 per month.

MACHINERY FOR HANDLING SMALL PACKAGES

By S. L. Haines,[1] Boston, Mass.

Non-Member

The above subject covers a very wide field, and involves many classes of conveyor machinery, but the intention is here to present an illustration of one of the latest developments in this line, namely, a novel method of handling magazines, the Saturday Evening Post and the Ladies' Home Journal, in the publishing house of the Curtis Publishing Company, Philadelphia. The same types of machinery, modified to suit conditions, may of course be used for the handling of light boxes, small packages, etc. In connection with the above examples I will also show the manner in which the mail bags, filled with the above magazines, are handled, by means of the various types of elevators, lowerers, conveyors, etc.

The magazine handling equipment consists in general of two duplicate lowering machines for the Home Journal, and two duplicate lowering machines for the Saturday Evening Post, with a belt conveyor distributing system in the delivery room for each pair of conveyors. Fig. 1 shows the arrangement of the machines as actually installed. Two of the lowerers are vertical machines about 73 ft. center to center of head and foot shafts and the other two have also a horizontal run of about 50 ft. Each lowering machine has two steel roller chains running over sprocket wheels as indicated, and have corner hung steel trays suspended between them and spaced 5 ft. apart. The trays have two sides, a back, and bottoms made with two slots running from front to back so that loading and unloading fingers can extend well back into them.

The loading is accomplished by automatic loaders at each floor. The magazines come from the trimming machines in stacks 3½ in. high and two of these stacks are placed together, one with the backs one way and the other with the backs the opposite way, making a 7 in. stack. These 7 in. stacks are then moved to the loading points where an attendant places them, one at a time, on the loading fingers, which, when at rest, are just outside the casings of the lowerers. The loaders are set opposite the ascending line of trays and each one is operated by means of a small auxiliary chain with a lug, or attachment, which engages with another lug on the main chain, just before a tray passes, thus working a crank and connecting rod mechanism that moves the fingers inward and directly over the slots in the tray. Each stack of magazines is then picked up by a tray, carried up and over the head sprockets and down to the automatic unloader in the delivery room.

In order that the loaders may operate only when

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magazines are placed on them, the lower shaft and sprocket of the auxiliary chain are arranged in such a manner that ordinarily they are back far enough so that the lugs will not engage and no movement of the loader takes place. It is part of the duty of the attendant, after placing a stack of magazines on a loader, to throw a lever which moves the lower shaft of the auxiliary chain forward into the engaging or operating position.

Further, it is obvious that with this system of loading, it would not be possible for a loaded tray to pass loading fingers in the forward position, since the slots in the tray bottom would be covered by the magazines. Since loading on the several floors at the same time was one of the requirements, it was necessary to make the loaders selective, that is arrange them so that they would pick out only empty trays. This was accomplished by arranging an arm, A, Fig. 1, at each loader so that it would pass through one of the slots of an empty tray but be thrown back by the magazines of a loaded tray and release a trigger which prevents the loader from operating.

The unloading is accomplished by having each descending tray deposit its load of magazines on two narrow moving belts which extend into the slots in the tray bottom, as at B, Fig. 1. These unloader belts, one of which is shown in Fig. 2, are located in the delivery room on the first floor, the ones from the two Post lowerers delivering to a single wide belt conveyor running between the mailing tables, and the ones from the Journal lowerers delivering first to a short belt conveyor and then to another belt conveyor at right angles and also running between the mailing tables.

At the present time the lowerers run up to the 5th floor with loading points on the 2nd, 3rd and 4th floors, but they have been built with the idea that they may some day be extended to the 8th floor. They are operated at a speed of 60 ft. per min., so that with the trays spaced 5 ft. apart this means a maximum of 12 trays per minute. A 7 in. stack includes thirty-six 92 page Posts or fifteen 124 page Journals, so that when handling magazines of this size each lowerer has a maximum capacity of 25,920 Posts or 10,800 Journals per hour.

The drive for the two lowerers, which is operated by one 7½ h.p. electric motor, is arranged so that the trays will deliver their loads of magazines at the proper alternate intervals to avoid interference when they are delivered to the same belt conveyor in the delivery room. It is so arranged that a spare motor can be thrown in on short notice in case of trouble with the other motor. The two belt conveyor systems in

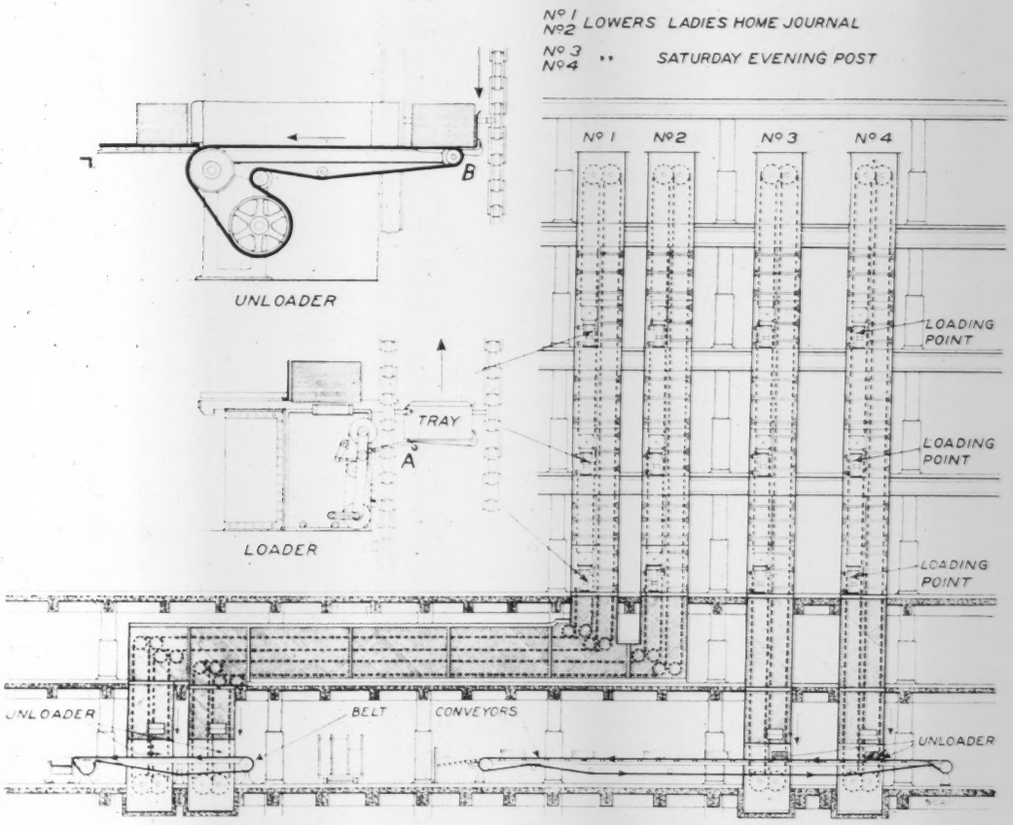


Fig. 1 Diagram showing Arrangement of a Large Installation of Magazine Handling Conveyors, with Details of Loaders and Unloaders

Fig. 2 View of one of the Unloading Belts in the Delivery Room

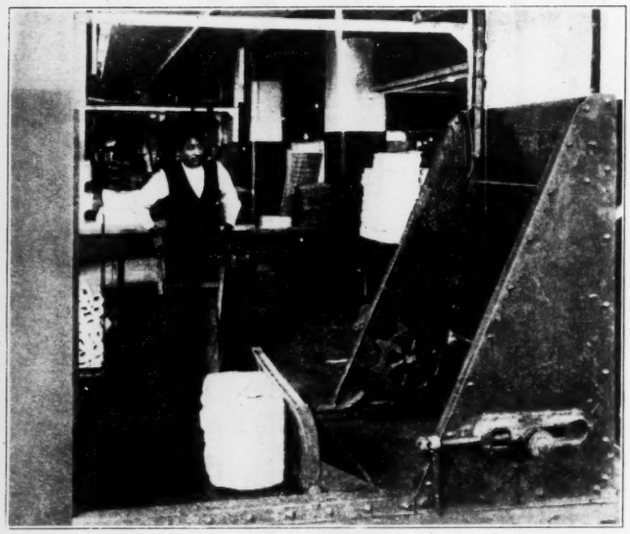
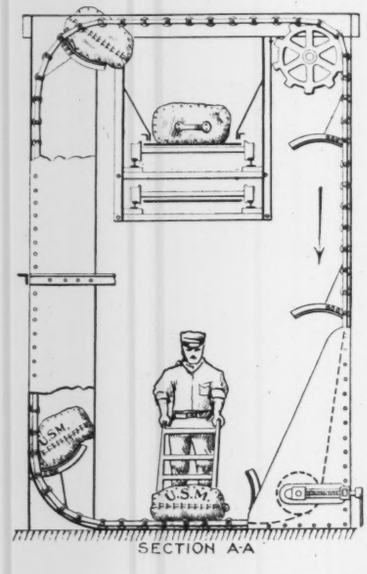


Fig. 3 View of one of the Mail Bag Elevators for raising Bags to the Horizontal Conveyor

the delivery room are each driven by a 1 h.p. motor.

The electric control system is arranged so that the machines can be started and stopped from any floor and each lowerer is equipped with counters at head and foot and on each loader, so that the number of stacks of magazines can be accurately counted and also that the counts from the different counters checked up to see that they tally and that none of them have been tampered with.

The mail bags are filled at the mailing tables in the delivery room, taken to the north end of the room and either stored on a mezzanine floor for a future shipment, or weighed and sent out at once. Since there are several hundred of these bags to be handled per hour, it would mean considerable labor and more or less confusion to truck them all the way through the room, besides which it is necessary to take part of them to the mezzanine floor. It was decided, therefore, to install three continuously moving chain and arm elevators, located at convenient points, and an overhead apron carrier, or moving platform, running to the north end of the room and delivering to the mezzanine floor. The attendant dumps the mail bags from his truck at the foot of an elevator, they are taken up and delivered to the apron conveyor, carried to the north end of the room and deposited on the mezzanine floor. Here a second man either places the bags in a certain compartment, according to their destination, or sends them down a chute to the weighers on the first floor.



These elevators, one of which is shown in Fig. 3, are of a special design arranged so as not to extend below the floor level and yet be easily loaded at the floor level. The chains are 6 in. pitch, steel bushed, steel roller chains and at intervals of 6½ ft., there are arms consisting of two brackets attached to the chain with pin connections to allow of flexibility and having curved steel plates across the full width. The path of the chains is shown in Fig. 4. When an attendant dumps a mail bag on the steel plate just above the floor,

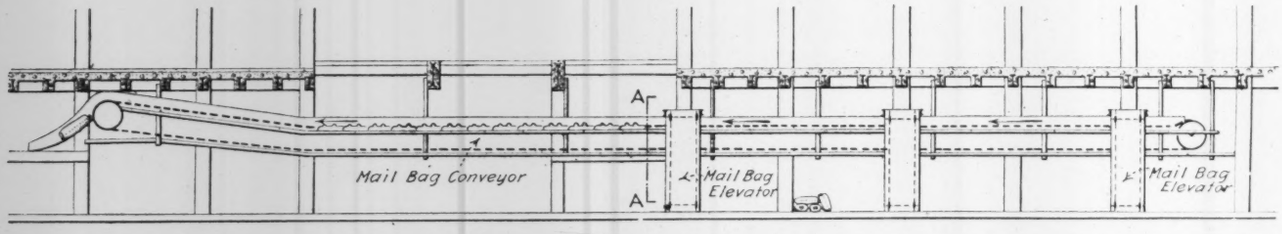


Fig. 4 Details of the Mail Bag Elevator and Arrangement of the Horizontal Bag Conveyor

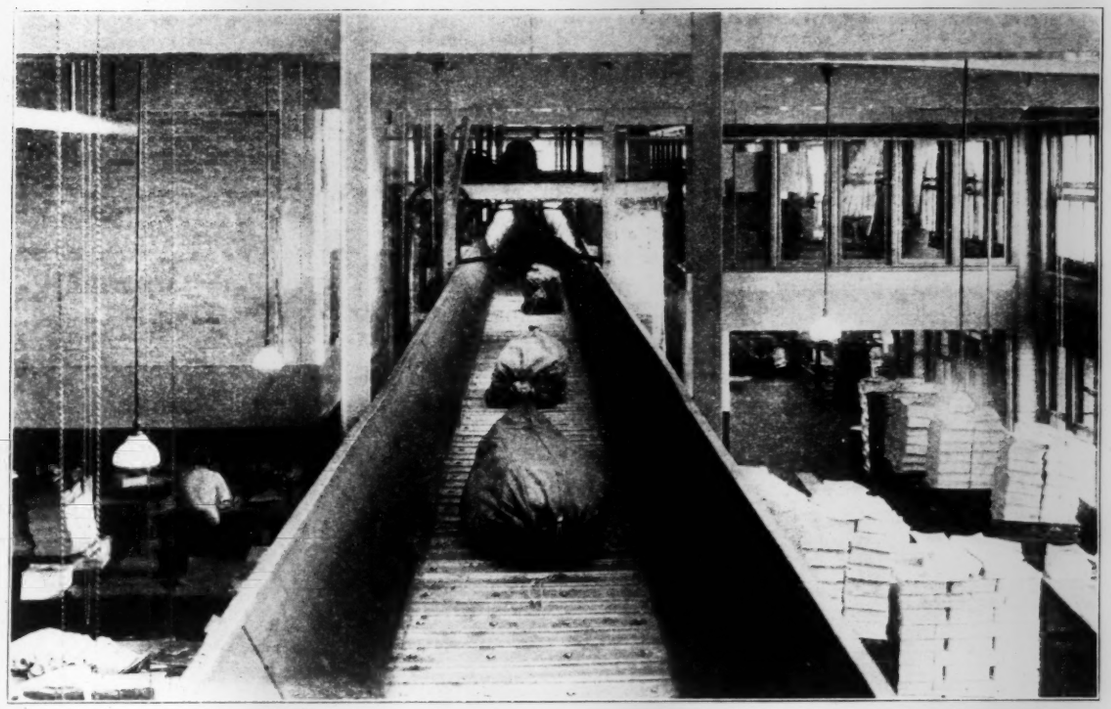


Fig. 5 View of the Horizontal Mail Bag Conveyor in Operation

an arm comes along and sweeps it up around the curve, carrying it up and discharging it at the upper turn so that it falls on the steel apron conveyor.

The apron conveyor, a view of which appears in Fig. 5, is made up with two 12 in. pitch, steel bushed, steel roller chains with corrugated steel slats attached to them so as to form a continuous apron 3 ft. wide. The mail bags ride along on the apron to the end of the

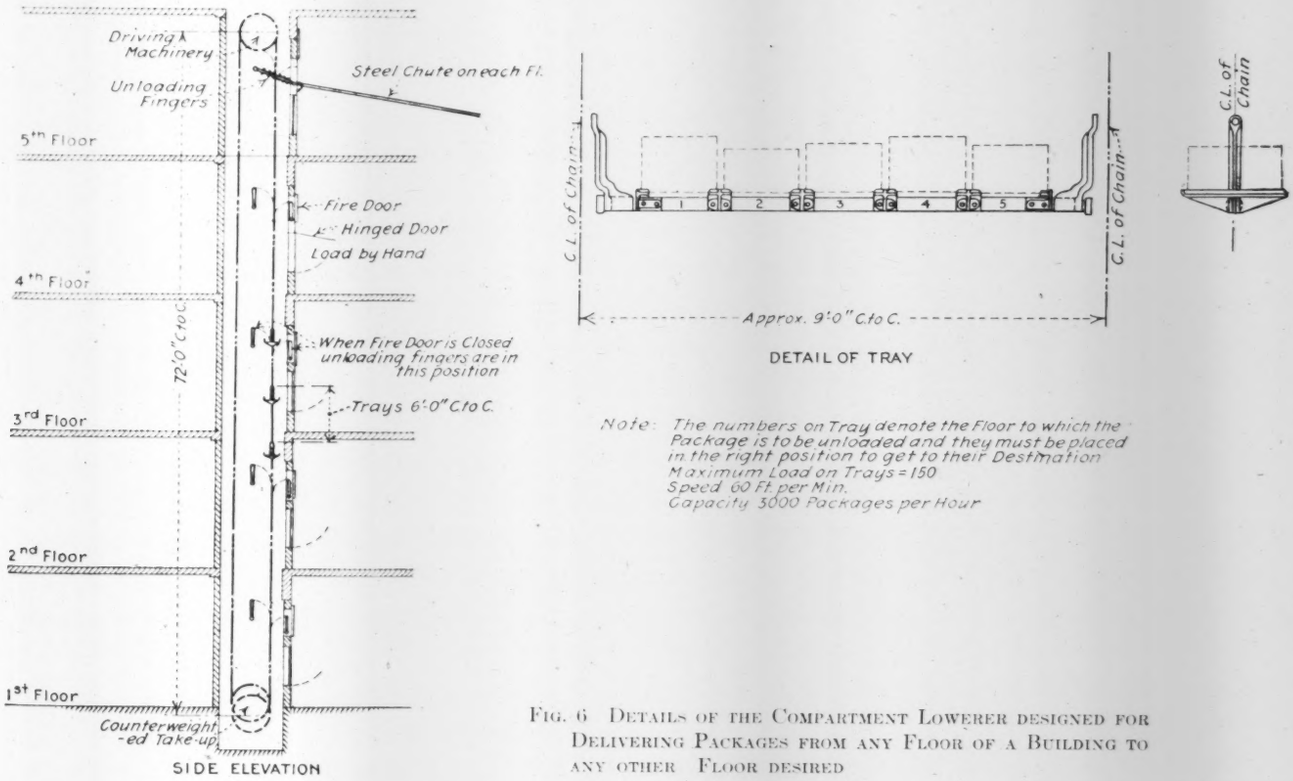


Fig. 6 Details of the Compartment Lowerer designed for Delivering Packages from any Floor of a Building to any other Floor desired

conveyor and fall off into a chute as the chains pass around the sprocket wheels.

The apron conveyor is 166 ft. long and operates at a speed of 80 ft. per min. It is driven by a 10 h.p. motor, and the speed reductions from this motor and also from the elevator motors are made by silent chain drives from the motors to the first counter shafts and then with cut gears.

Each elevator is driven by a 3 h.p. motor, and at a speed of 65-ft. per min., has a capacity of 600 mail bags per hour, the maximum weight of the bags being about 200 lb.

Fig. 6 shows a later type of elevator and lowerer, known as the compartment lowerer. It will be seen that the tray of this conveyor is made up of five compartments, and the building in which it is used is five stories high. The machine is used where boxes are loaded from various floors and it is the wish to unload at various floors. Each compartment has a number corresponding to a different floor. Material put on at any floor and assigned to the fourth floor, would of course be put in the fourth compartment, and at that point would be automatically discharged by the roller fingers as shown opposite the fire door openings. The speed is 60 ft. per min. and the capacity about 3000 packages per hour.

THE POWER PROBLEM IN THE ELECTROLYTIC DEPOSITION OF METALS

BY H. E. LONGWELL, PITTSBURGH, PA.

Member of the Society

THE meeting of the Society in New York on January 9, 1914, was a joint meeting with the American Institute of Electrical Engineers and the American Electrochemical Society, at which was held a symposium on the subject of Electrolytic Deposition of Metals. Lawrence Addicks, Mem.Am.Soc.M.E., representing the American Electrochemical Society, delivered a paper on Limitations of the Problem of Electrolytic Deposition, while F. D. Newbury, of the American Institute of Electrical Engineers, presented a paper on Sources of Direct Current for Electrochemical Processes. H. E. Longwell, Mem.Am.Soc.M.E., read a paper on the Power Problem in Electrolytic Deposition of Metals, in which he discussed some interesting phases of the problem of power production in industries of this class. His remarks are presented below in abstract form.

In dealing with any technical problem, common sense is most useful; but technical knowledge without common sense is disastrous. I want to emphasize the fallacy of attaching too much importance to the question of mere fuel economy in a power plant, because I think there is a little tendency in this direction in the presentation of the problem that has been submitted as a foundation for this discussion. Sundry estimates are submitted as representing the problem cost of steam and electrical energy, exclusive of administration, taxes, depreciation and interest charges. The items of interest, taxes, insurance and depreciation, or more exactly, amortization, are too important to be ignored. These so-called fixed charges, or investment costs, are in general greater in amount than the total cost of labor, operating supplies and maintenance. They are especially significant in that they measure the cost of fuel economy.

To illustrate, let us consider the probable comparative performances of a high grade steam turbine plant, and a gas engine and producer plant, consisting of several 1500 kw. generating units. The electrolytic refining industry offers any investment in the interest of economy, an unusually favorable opportunity to "make good," because the investment is permitted to work at its utmost intensity continuously 24 hours per day every day in the week.

Assuming the fuel to be the highest grade of bituminous or semibituminous coal, having a calorific value of 14500 B.t.u. per lb., the gas engine and producer plant, would, under test conditions, effect a saving of ½ lb. of coal per kw-hr. over the turbine plant, or say 2 tons per annum. If the coal costs as much as $3 per ton this would mean a saving of $6 per kw-year.

The gas engine and producer plant will cost about $50 per kw. more than the steam turbine plant, and the question arises as to whether it is worth while to invest $50 in plant to save $6 a year. Naturally there will be differences of opinion as to what would constitute an attractive return on this extra investment. For my own part, I should want 6 per cent for interest, 1 per cent for taxes, 1 per cent for insurance, and 2 per cent for maintenance. Having due regard to the appalling speed with which new things in engineering become old, I shouldn't feel comfortable unless I had a sinking fund of 8 per cent to provide for the safe return of my capital. The sum of these items amounts to 18 per cent. Even with this gross return assured, I think I should be inclined to regard a 6 per cent mortgage as a more attractive investment. In my own opinion the gross return should be not less than 20 per cent per annum, so that this saving of $6 per kw-year would be too expensive if it required an extra invest-

ment of more than $30 per kw. in plant equipment. Those who are interested in the determination of the true cost of electrical energy will profit by reading a paper, Standardization of Method for Determining and Comparing Power Costs in Steam Plants, presented jointly by Messrs. H. G. Stott and W. F. Gorsuch, at the June 1913 meeting of the American Institute of Electrical Engineers.

With respect to the type of power plant best suited for the electrolytic refining of copper, I think we may safely eliminate the gas engine equipment from serious consideration. If the plant will be located where there is an abundant water supply available for condensing purposes, and where the cost of fuel is reasonable, such as to enable a steam plant to display its best economy, the gas engine plant would be a doubtful investment, even were there no especial reason why it is not desirable for this particular class of work. There appears, however, to be one reason why the proposition is peculiarly one for a steam plant, which is based on premises supplied by those actively engaged in electrolytic copper refining. According to Mr. Addicks' statement of the problem, if live steam were used for heating the electrolyte, the total steam from the boilers would be used as follows: One-half for electric power generator, one-quarter for steam driven auxiliaries, and one-quarter for heating the electrolyte. Steam driven auxiliaries are not as a rule so efficient that they abstract any serious amount of heat from the steam passing through them, so that for the purpose of heating the electrolyte, the exhaust from these auxiliaries would be practically as effective as an equal quantity of boiler steam. Therefore the boiler steam required for auxiliaries and for heating the electrolyte, would be approximately 50 per cent of the amount required for generating the electric current.

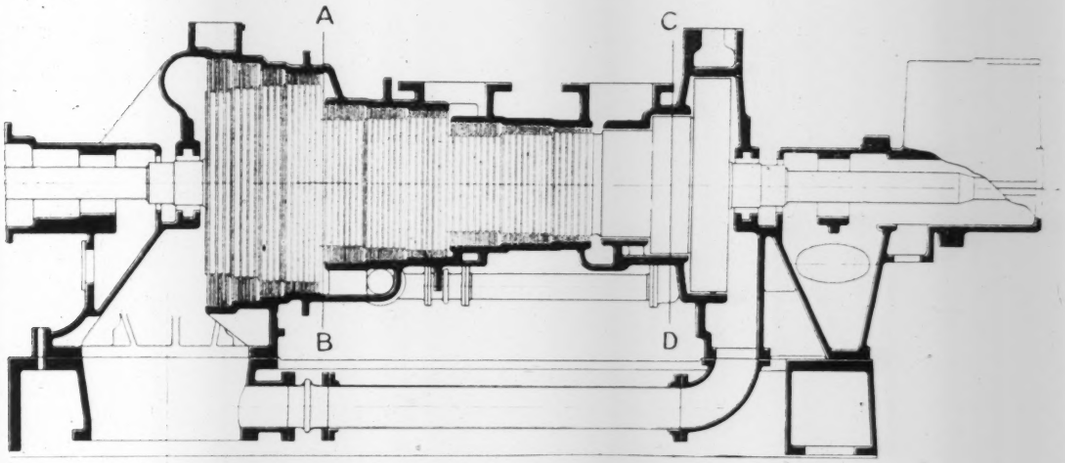


Fig. 1 Sectional View through a typical expansion steam turbine of the Parsons type

I am informed by the general manager of one of the largest refineries in this country that in a plant having an output of 500 tons of refined copper per day, the waste heat boilers connected to the reverberatory furnaces forming a part of such a plant, should be capable of supplying 50,000 lb. of steam per hour. This is somewhat over 40 per cent of the steam required by the main generating units, or practically enough to op-

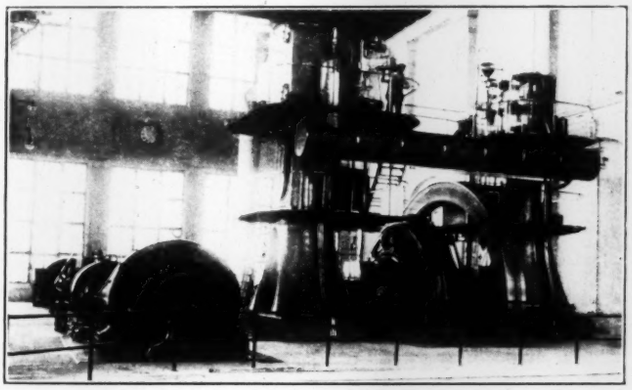


Fig. 2 A 1500-kw. gear-driven turbo-generator installed beside a reciprocating engine set of same nominal capacity

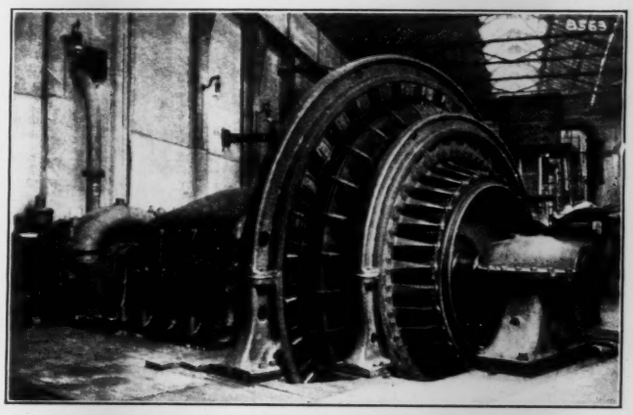


Fig. 3 A 3000-kw. gear-driven direct-current turbo-generator operated by the Cleveland Electric Illuminating Company

erate all of the auxiliaries that would usually be run by independent steam motors in a steam driven plant, and the exhaust from these auxiliaries would take care of the heating of the electrolyte. This quantity of steam is too important to ignore and even though gas-engine driven main generating units were installed it would be necessary to make use of this steam from the waste heat boilers.

As I understand it, the practical difficulty arises from the fact that while the tanks are operated continuously, it is not usual to run the furnaces on Sunday. Consequently it would be necessary to have a considerable boiler plant in reserve to be operated only one day in each week for the purpose of tiding the plant over Sunday. And so even if there were no question as to the commercial economy of a gas engine and producer plant as a general proposition, this one practical operating condition would be sufficient to rob it of all of its theoretical advantages. In a steam plant the regular boiler equipment is so flexible that it will readily take care of the fluctuations in the output of the waste heat boilers. Since with modern mechanical stokers it is not unusual to force boilers to 200 and 300 per cent of their normal rating, it is evident that no decidedly disproportionate boiler equipment would be required to carry the plant over the weekly interval in which the waste heat boilers are out of commission.

The combination of a compound reciprocating engine exhausting into a low-pressure condensing turbine looks on first consideration to be inviting, since it is generally admitted that between the limits of the usual boiler pressure and atmospheric exhaust pressure, a reciprocating engine is usually more efficient than it is customary to make the portion of a complete expansion turbine that takes care of this part of the pressure range. While the superior fuel economy of this combination seems very apparent from purely theoretical considerations, there is comparatively little available information regarding its amount in actual figures. It is not denied that this combination has its legitimate uses, but it is most certain that mature judgment is required for determining the conditions under which it may be recommended.

Admitting the hypothetical economy of the combination, let us consider the features that tend to offset this advantage. We have first increased initial cost. A low-pressure turbine will in many instances cost 75 to 80 per cent more per kw. than a complete expansion turbine. That this is reasonable may be seen readily by an inspection of Fig. 1, which is a sectional view through a typical expansion steam turbine of the Parsons type. Let us assume that the capacity of this machine is 3000 kw. What we must do to convert this 3000-kw. turbine into a low-pressure turbine of half this capacity, is simply to cut out that portion included between the two vertical lines *AB* and *CD*, and increase the inlet opening some six or eight times. Now it does not require any unusual qualifications to see that the part eliminated does not by any means represent one-half of the cost of the 3000-kw machine. Neither would any one of reasonable intelligence expect to purchase 1500-kw. capacity in a reciprocating engine for any sum remotely approaching the cost of the section that has been eliminated from the complete expansion turbine. Again, no one would seriously claim that the expense of installing the combination unit would be less than twice that of installing the single complete expansion unit, and no one would suggest that the charges for attendance, maintenance and operating supplies would be approximately equal for the two units.

There are, doubtless, cases in which the possibility of conserving reciprocating engines already in use would justify this combination type of unit, but in a plant that is new throughout its desirability is, to say the least, highly problematical. The most important installation of combination units in the world was carried out under the direction of Mr. Stott. He had the

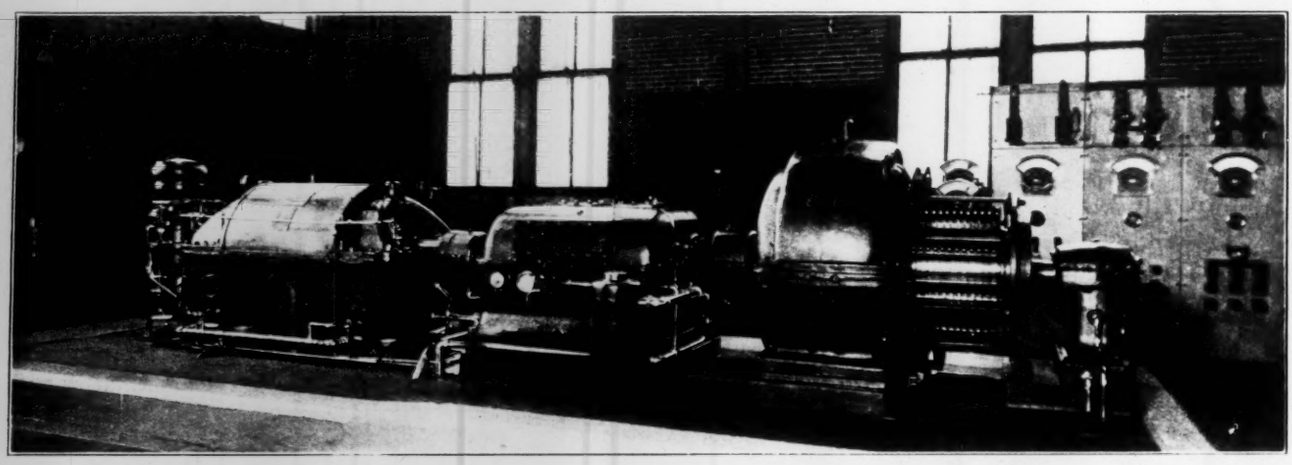


Fig. 4 A 750-kw. gear-driven direct-current turbo-generator in use by the Louisville & Nashville R. R.

justification of conserving valuable reciprocating engine equipment which was in excellent physical condition, and there can be no question that the best possible engineering judgment was exercised in designing and executing the project.

As regards the comparative merits of compound and triple expansion reciprocating engines, and turbines, as prime movers, the trend of general practice in power plant design shows pretty conclusively that the turbine has the advantage. It has economic possibilities equal at least to those of the reciprocating engine, and markedly better when working with the high vacuums obtainable with the newer types of condensing apparatus and the copious supply of cooling water that is invariably found in places that would be regarded as favorable locations for electrolytic copper refining plants.

I speak of the economic possibilities of a certain type of prime mover rather than of its inherent economy, because the latter is inseparably associated with the type. A prime mover is not economical simply because it is a compound engine, a triple expansion engine or a turbine, but because it is economical by design. There are hundreds of triple expansion engines that are less economical than some compound engines. In fact I am not sure that there are authentic records of triple expansion engines which show sufficient improvement over the economic results of the best examples of two-cylinder compound engines to justify the added complication and expense of the third cylinder and its connections.

It is possible to design a turbine that will be less economical than a very ordinary multiple expansion reciprocating engine. On the other hand turbines are built that under suitable operating conditions give economic results that cannot be equalled by reciprocating engines of any type, however skilfully designed, if operated under the same conditions. The advocates of the turbine can afford to be unnecessarily modest, and claim no more than equality with other types of prime mover as regards steam economy, for there remain still the unquestioned advantages of lesser cost, and smaller installation expenses.

For some years the turbine was at a disadvantage in plants in which it was desirable to generate direct current, for the reason that the rotative speed of an efficient steam turbine, and the rotative speed of a reliable efficient direct-current generator are not compatible. This inability has happily been removed by the development of a reliable transmission gear, which allows any reasonable speed ratio between the turbine and the generator. This gearing has an efficiency of over 98 per cent, and has been in public use long enough to demonstrate that in point of reliability and durability it is at least on a par with any other kind of apparatus installed as a part of an electric power plant.

Fig. 2 is a view of one of two 1500-kw. geared sets installed at San Diego, Cal. The illustration gives a good idea of the size of this unit as compared with an engine driven set of approximately the same nominal capacity. One of these sets was in regular service two years on September 3, 1913, and the second was in service two years on February 15, 1914. Fig. 3 shows one of two 3000-kw. geared direct-current turbo-generator sets installed for the Cleveland Electric Illuminating Company. One of these sets was put in service a year ago January 20, 1914. It is fair to say that in this case the exhaust of the turbines is used for district heating, and the units operate only during the heating season. Fig. 4 shows a 750-kw. set owned by the Louisville & Nashville Railroad Company, which has been in service just about one year. In addition to the sets illustrated, I might mention six others of 750 and 1500 kw. capacity, all of which have been in regular service for more than two years, and the oldest of which will have been in service three years on April 4, 1915.

While the geared direct-current unit costs more than an alternating-current turbo-generator unit of the same capacity, it is cheaper and somewhat more efficient than the combination of an alternating-current unit and rotary converter. I am not in possession of reliable costs for compound reciprocating engine-driven units, but commercial experience indicates that the geared turbine-driven unit has an advantage as regards price at the factory. With freight and installation costs added, the advantage is obviously more marked.

Figures purporting to give probable plant and unit power costs are as a rule unsatisfactory because they are affected by too many variable factors. As regards plant cost, it might be said that depending on the expensiveness or simplicity of one's architectural tastes, his luck in selecting a contractor, his resourcefulness as a designer, his finesse as a buyer, the accessibility of the site selected, the state of the weather, etc., he ought to be able to build a really good turbine-driven plant of from 6000 to 9000 kw. capacity, for around $75 per kilowatt.

As regards the cost of power: if one is satisfied with investment charges of 10½ per cent per annum, if he can buy really good coal at not to exceed $3 per ton, if he is a capable manager and a careful operator, and reasonably economical, he ought, with a plant of this size, to be able to produce a kw-hr. at the switchboard with substantially 100 per cent load factor, for around 4.3 mills.

NOTES ON THE FLOW OF OIL IN PIPES

BY E. I. DYER,[1] SAN FRANCISCO, CAL.

Non-Member

At a meeting of the San Francisco Section of the Am.Soc.M.E., held February 10, the topic for discussion was The Transportation of Crude Oil in Pipe Lines. E. I. Dyer, engineer-in-chief for the Union Oil Company of California, led the discussion by reading a paper prepared with special reference to experimental work on one of the oil pipe lines of his company, to determine the various factors influencing the loss due to friction in pumping oil through pipe lines, and the derivation of formulae by which the friction losses could be calculated. An abstract of the paper and report of the meeting is given herewith.

An oil pipe line is primarily an investment, and as such, exists for the purpose of enabling its owners to derive profit either directly from the operation of the line itself, or from other associated enterprises. The time element has always been an important consideration in its construction. In this state, the production of oil has increased at such a rapid rate and with such suddenness at times, that it has been absolutely necessary to build long pipe lines on short notice, and these conditions have unfavorably influenced their design by putting a premium on practice which, while not usually preventing the pipe line from being constructed with reasonable certainty of success as an investment, has too frequently not resulted in the most profitable investment possible.

Fortunately, undertakings of this character have been safeguarded as a rule by a variety of favorable circumstances tending to offset mistakes of design. One of these has been the absence of competition, due to the costly nature of operations on a scale sufficiently large to render such competition effective, and another has been that experience has developed an empirical practice which provides reasonable protection against a considerable variation in physical conditions. As a rule, builders of pipe lines have been content to follow closely in the footsteps of others, so that we see on every hand too much slavish imitation and rule-of-thumb engineering, with too little evidence of initiative. As a matter of fact, the immense number of variables to be dealt with, particularly with California oils, is enough to warrant a great deal of conservatism. The necessity for quick action has made designers of pipe lines the victims of circumstances, and the multifarious duties exacted of most engineers connected with oil companies, together with a general lack of sympathy with research work, has discouraged investigation of the fundamental variables which are at the bottom of all pipe line design.

Hence it is that, as a rule, the oil pipe line in California, regarded either as an investment or as a purely physical problem, does not always represent the best possible solution that might be made for exactly the same conditions. The most economical pipe line for a given service cannot be determined in advance without a working knowledge of the laws governing the flow of oil in pipes in general. The determination of these laws offers the most important single problem in connection with pipe line work. Everything else depends on it. Unless the loss of head by friction can be predetermined with reasonable accuracy, every element entering into both the first and the operating costs of an installation is uncertain, and should the design be undertaken in an era of keen competition and small margins of profit, a losing venture might easily result.

In view of the importance of this phase of the subject, this discussion is confined as far as possible to points bearing upon the friction head in oil pipe lines. Neither a full nor a general analysis is attempted, nor is anything offered purporting to be a complete and final solution of the problem. The information offered is of a fragmentary and tentative character, based on observations unfortunately subject to considerable error, as will appear later, and it is hoped that it will promote discussion and stimulate investigations which the importance of the subject demands, and if possible, at the same time, be suggestive of an avenue of approach toward a logical and complete method of determining the friction head for any given oil under any given conditions.

The problem of piping oil differs from that of piping water primarily in the fact that, whereas water is a fluid of well-defined and of almost constant physical characteristics within ordinary temperature limits, oil is quite the opposite; no two oils are exactly alike and even any one oil is subject to important physical changes under variable temperature. While the flow of water through pipes offers in itself a sufficiently difficult problem, still the laws governing it have been determined empirically with sufficient exactness to meet all ordinary, practical requirements. For present purposes water may be considered as a liquid of almost negligible viscosity at all ordinary temperatures, although this is not strictly correct, as will appear later. Oil, on the other hand, is a liquid of relatively great viscosity, much affected by change of temperature. The principal difference between the two

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from a pipe line point of view lies in this question of viscosity and it is logical to suspect that any solution of oil flow problems will be found to involve viscosity in some form or other.

Viscosity may be defined as that property of a liquid which causes it to offer resistance to relative motion of its parts and to change of form. More specifically, it has been defined by Clerk Maxwell as "the tangential force per unit area of either of two horizontal planes at the unit of distance apart, one of which planes is fixed, while the other moves with unit velocity, the space between being filled with the viscous liquid."

The viscosity of any liquid may be measured in the laboratory and can be expressed either as absolute viscosity in c.g.s. or gravitational units, or else in some empirical unit. An arbitrary unit is more convenient for practical purposes, as simple apparatus may be used and no computations are required. The instrument used is known as a viscosimeter or viscometer. The type which finds most general application in this country consists of a cylindrical vessel of known volume and form surrounded by a water jacket which may be maintained at any desired temperature. At the bottom of this vessel is a small circular orifice of definite dimensions with a definite form of entrance. A measured quantity of the liquid to be tested is put into the vessel and the time required to run through the outlet in seconds is taken as the viscosity of that liquid at that temperature. Thus, if the time is 30 seconds, the viscosity is called 30. This figure in fact represents the approximate viscosity of water at a temperature of 60 deg. fahr., and a typical fuel oil of 16 deg. to 17 deg. Bé. has a viscosity of about 9000 at the same temperature.

It will be seen that the phenomena occurring in this instrument do not differ radically from those in a pipe line except that the entrance effects are relatively large and the operation is on a small scale, under variable head and under constant temperature. As previously indicated, the viscosity of oil varies over a wide range with change of temperature. Thus, a certain oil of 16.6 deg. Bé. gravity has a viscosity of 200 at 200 deg. fahr. and about 13,000 at 50 deg. fahr. In other words, at the lower temperature it takes 65 times as long to flow through the standard orifice as it does at the higher temperature. The curves in Fig. 1 illustrate the change of viscosity for several crude oils with change of temperature. It is worth noting in passing that the heavy and the light oils tend to show about the same viscosity at a temperature of 200 deg. fahr., and as we have seen that viscosity is the measure of the resistance of an oil to change of form, these curves should convey a lesson to those who are interested in cutting down the steam required for atomizing oil in burners. The same sheet also shows the effect of change of temperature on water; although the change is not great as compared with oil, still it is quite noticeable.

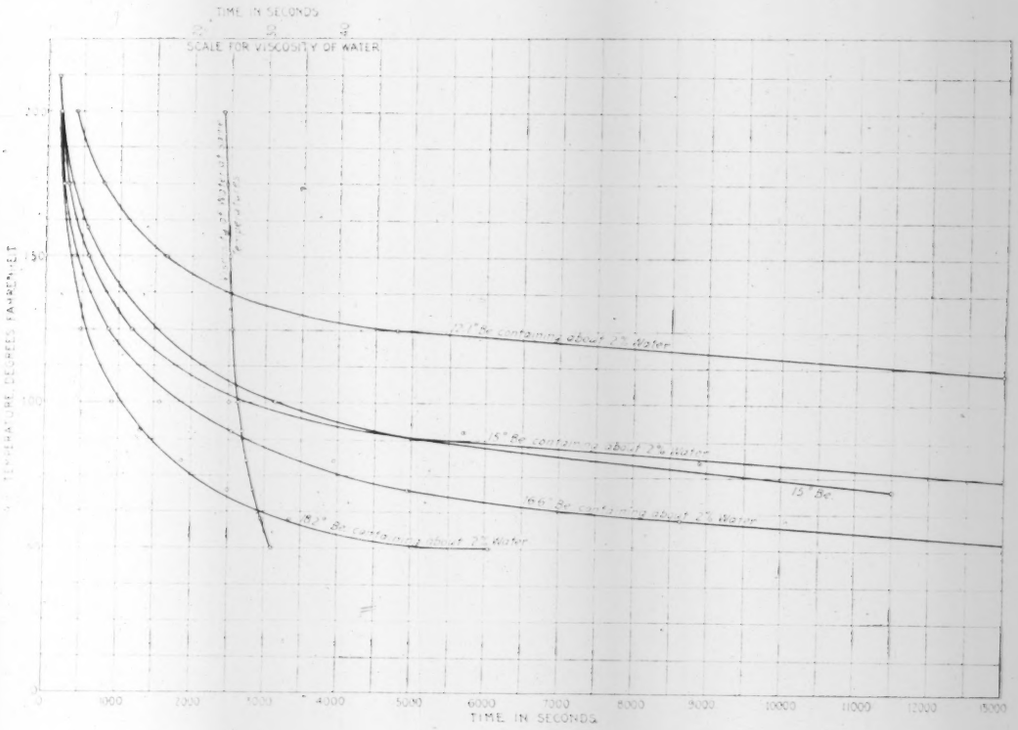

Fig. 1 Curves showing Relation of Viscosity to Temperature in Several Different Crude Oils

Having noted the effect of temperature variation on the viscosity of oil, it will be instructive to make similar observations on the effect of temperature on the

resistance to flow of oil in pipe lines. In making these observations it has been convenient to use the Chezy formula in the form given by Unwin for use with water. This formula is largely used by engineers and may be expressed as follows:

$$h = 0.1008 \frac{\varsigma Q^2 L}{d^5} \quad \ldots\ldots\ldots\ldots [1]$$

Where ς = an arbitrary coefficient depending on diameter, velocity and roughness of surface
h = loss of head, feet
Q = quantity, cubic feet per second
L = length, feet
d = diameter, feet

Transposing, we have

$$\varsigma = \frac{hd^5}{0.1008 Q^2 L} \quad \ldots\ldots\ldots\ldots [2]$$

By use of this last expression, ς can be determined without difficulty for any oil in a pipe line by a series of observations, for any temperatures, size of pipes, rate of flow, etc. At the same time the viscosity of the same oils over the same range of temperatures can be determined with a viscometer. Two sets of curves can then be plotted, one showing the relation existing between temperature and ς as observed in a pipe line and the other, the relation between temperature and viscosity as determined by the viscometer. From these curves two empirical equations may be determined and t (temperature) eliminated, giving ς in terms of viscosity. By substituting this value of ς in equation [1] we would then expect to have an expression of the form

$$h = \frac{cQ^2 L f(\eta)}{d^5}$$

where c is a constant and $f(\eta)$ represents some function of η, the coefficient of viscosity. By a series of tests we might reasonably expect to be able to determine by these means such constants as would enable us to predetermine the drop in pressure for any oil in any pipe line by measurements of viscosity made in the laboratory.

To make the determinations covering all possible conditions naturally requires an extensive equipment, patience and sustained effort. I have already indicated some of the obstacles in the way of the engineer of the oil company, preventing work of this character being done. Nevertheless it has been possible to keep records of everyday operations which afford some approximation to accuracy. In one place which I have had under observation for some years there are two oil pipe lines respectively 6 in. and 8 in. in diameter and about 2 miles long, which are in intermittent service as occasion demands, carrying a variety of oils, usually at a fairly constant rate of about 500 bbl. per hour. The temperatures available and the rate of flow are such as commercial considerations dictate, so that it has been impossible to make changes for experimental purposes. The mean temperature in the pipe line averages about 110 deg. fahr. The lines are buried for practically their entire length, although they are exposed for considerable distances, and for the most part they are practically straight. They are equipped with gages and thermometers and the elevations are of course known. The gages are of ordinary commercial type and therefore at times very unreliable, but they are, however, calibrated at more or less frequent intervals by a standard gage which is itself checked from time to time on a dead weight tester. Errors of pressure have undoubtedly crept in; the observations as to quantities, temperatures, etc., are made by the regular operators and are also known to be inaccurate at times. In general, commercial requirements do not permit of the conditions being varied at will for purposes of test

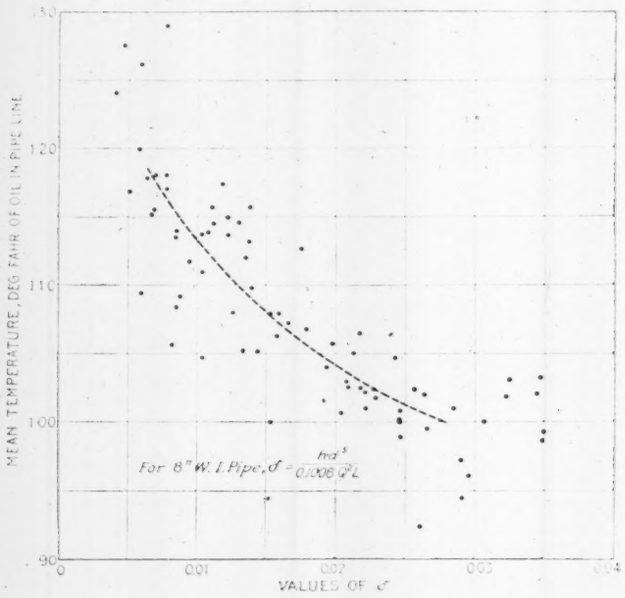

Fig. 2 Curve showing Approximate Relation between Value of ς and Temperature in 8-In. Pipe Line

and in other respects they are not ideal. It is particularly unfortunate that higher rates of flow and ranges of temperature have not been available, but their absence should not interfere with the general truth, of the deductions which I am about to make.

Values of ς have been computed for the two lines for some 120 or more runs. Those for the 8 in. line have been analyzed and tabulated and the results given here are for that line. Values of ς have been plotted against temperature as shown in Fig. 2, the temperature used being the arithmetical mean of the temperatures at both ends of the line. The logarithmic mean would probably give greater accuracy but there are so many other uncertainties that it is probable that the fall of temperature in the line is not strictly uniform anyway. The oil represented in the t-ς curves varies in gravity from 16 to 17 deg. Bé. There are a few freak points, but on the whole a fair curve can be drawn which is reasonably representative of the average.

While the curve may not be strictly correct, it is evident that it unmistakably shows that ς decreases regularly with increase of temperature.

If we compare the t-ς and t-η curves we will at once be impressed by their similarity and if we examine the viscosity curve for 16.6 deg. Bé. oil, particularly that portion which lies between the same temperature limits as the t-ς curve, it will be seen that the similarity is very striking. In fact, plotting the two on the same sheet with the same temperature scale and the ς scale suitably adjusted, the curves can be made practically to coincide. By means of this expedient I have deduced the relation

$$\varsigma = \frac{\eta - 930}{30667}$$

Now if this value of ς be substituted in equation [1] we have

$$h = \frac{Q^2 L \ (0.001075 \ \eta - 1)}{327 d^5} \quad \ldots\ldots [3]$$

This relation has been checked in several instances and the agreement with observed facts was as close as might be expected under the conditions. You will notice that with viscosity of 930 the expression becomes zero and indicates one of the limits of the formula. The formula is not proposed for serious use, but is given as a sample of one method of approach. With an accurate series of observations there is no reason that I see why a formula cannot be developed in this way to cover all conditions. If we inspect the temperature — viscosity curves again it will be seen that what is true of 16.6 deg. Bé. oil between the temperatures of 100 and 120 deg. appears also to be approximately true for

12 gravity oil between 145 and 165 deg.
15 gravity oil between 110 and 140 deg.
18 gravity oil between 75 and 100 deg.

because the curves are of the same form and general slope between those temperature limits.

I have digressed slightly from the course I had mapped out, wherein I had intended to show how ς might be expressed in terms of η by equating the value of t found from the empirical equations of the temperature-viscosity and temperature-ς curves.

H. E. Boner, engineer of tests of the Union Oil Company, has developed the empirical equations for both the sets of curves shown, and finds that the equation of the t-η curve is

$$\eta = \frac{(584.5)^{5.42}}{(t + 50)} + 65$$

from which

$$t = \frac{584.5}{(\eta - 65)^{0.1843}} - 50$$

He has also derived the empirical equation for the t-ς curve, which is

$$\varsigma = \left(\frac{70}{t + 5}\right)^{8.81}$$

from which

$$t = \frac{70}{\varsigma^{0.1135}} - 5$$

By equating the two values for t thus obtained, the value of ς is found to be

$$\varsigma = \left[\frac{1.555}{\dfrac{13}{(\eta - 65)^{0.1843}} - 1}\right]^{8.81}$$

Substituting this value for ς in equation [1] we have

$$\eta = \frac{0.1008 Q^2 L}{d^5}\left[\frac{1.555}{\dfrac{13}{(\eta - 65)^{0.1843}} - 1}\right]^{8.81}$$

This expression gives values for the lost head somewhat higher than the relation first deduced in equation [3] and as far as it has been checked, with no greater accuracy. It, however, offers greater promise of extension over a wider range of temperatures. It will be noted that it does not become zero until the coefficient of viscosity becomes as small as 65. I might say that the t-η and t-ς empirical equations when plotted give curves agreeing very nearly with the curves plotted from the original points. In considering these equations, it should be borne in mind that they are developed from a limited series of tests made on but a few oils over a narrow temperature and velocity range.

If an attempt is made to apply them to conditions differing materially from those under which the runs were made, it will be found that correct results will not be given. Therefore I wish to emphasize the point that I have not been attempting to offer a solution of the problem, but rather to indicate a promising method for arriving at the solution. The velocities used in the above determinations are lower than those found in practice in the field, and this is an important point of difference. The same method of development can be employed to determine the effect of velocity, but this has not been done as yet. I feel certain, however, that the methods indicated if carried out on an extensive scale and under test conditions, can be made to yield reliable results and if this actually proves to be the case, the starting point in pipe line design may be in the laboratory, commencing with the viscosimeter.

DISCUSSION

Wynn Meredith. The commercial considerations have, as Mr. Dyer has stated, prevented the obtaining of precise data of existing lines as to the governing factors in the pumping of California oils. The development of empirical formulae to fit conditions within certain limits is very interesting. The temperatures used in pumping California oils run from about 140 deg. fahr. down to whatever it comes to at the delivery station, the stations being usually 12 to 14 miles apart. This temperature is about as high as can be used with the light oils without losing valuable gases; with the heavier fuel oils the temperature can be raised very much higher without serious loss, because they have very little to lose.

The general practice in pumping is to have about 800 lb. pressure at the initial station. Aside from the distances between stations, the rate of loss of heat is largely affected by the nature of the ground traversed by the pipe line, and has a governing effect upon the proper location of stations. One

curious thing that happens in pumping heated heavy oils in a line with a normal capacity of say 20,000 bbl., is that when operating at a rate of from 6,000 to 8,000 bbl., the initial pressure is actually greater than it is when pumping up to 15,000 or 20,000 bbl. This follows naturally, because at the higher rate the oil carries the heat further and maintains a greater fluidity throughout the line. But it is rather curious to see a pump working under one-third capacity with a pressure even greater than when running at full capacity.

The economic pumping of heated California oils requires, among other things, the proper locating of pumping stations with reference to distance between stations, due consideration being given to differences in altitude. A correct formula for the determining of friction head would be of great value in the calculations. Experience with existing lines has shown the limitations to a considerable extent. Fortunately, the errors of calculation with present knowledge are capable of fairly simple correction by the addition of somewhat larger pipe on the delivery end in the event of stations being located slightly too far apart.

The method of equalizing different divisions of a pumping line may also be used to maintain the capacity when it is required to pump heavier oils, which usually follow upon the decline of an oil field. This method of correction is exactly similar to that used in electric circuits, wherein the load is increased beyond originally calculated quantities, and additional copper is inserted to keep the drop within economic limits; only, in the case of an electric circuit, the copper is usually put on the pumping end instead of the delivery end, the latter location being more efficient in the case of a hot oil line on account of temperature conditions.

H. W. Crozier. I have been doing considerable work on this problem, but have attacked it in an entirely different way. Instead of attempting to calculate the head only, I have been calculating the hydraulic grade for a whole pumping unit, that is a pumping station and the pipe extending to the next pumping station. The hydraulic grade line which the hydraulic engineers have used for many years is a familiar device. It consists of a sloping straight line so drawn that one end intersects the surface of the water in the reservoir supplying the pipe under consideration (neglecting entrance losses) and the other end coincides with the surface of the water in the terminal tank or reservoir. The distance between the hydraulic grade line and the pipe at any point is proportional to the pressure at that point and the slope of the line is proportional to the friction loss in the pipe.

When considering heated California oils instead of water, the hydraulic grade line is no longer a straight line but a curved line which droops as the distance from the pumping station increases, due to the drop of temperature caused by heat losses due to radiation and conduction through the ground in which the pipe is laid. The reason I have been giving so much consideration to the hydraulic grade phase of this matter is on account of the fact that we have been working on mountain pipe lines; these are altogether different from valley lines, where certain definite conditions exist in each station. On one mountain line surmounting a considerable summit, four pumping stations, only a few miles apart, pump the oil up the mountain slope to the summit while on the down-hill slope the stations are spaced from 18 to 26 miles apart, depending on the slope. Pumping stations on this same line serving relatively level sections are 13 miles apart.

During the construction of that line everybody foresaw trouble in getting the oil uphill. My contention was that the limitation of the line would be, not in getting the oil up the hill, but down, my reason being that there was ample heat in the oil to keep the temperature high enough to hold the oil in a fluid condition in the 6-mile ascending sections; but in the 22 and 26-mile descending sections it was a different thing altogether, as the curves in Fig. 1 illustrate very clearly. As the temperature drops due to loss of heat the viscosity increases with increased rapidity; hence on the long descending sections the friction increases rapidly and a limit is reached at which it is necessary to install a pumping station with its heaters to pump the oil along. By using a hydraulic grade line platted as accurately as possible, this can be laid out on the profile of the line, and the pumping stations located with considerable accuracy.

Referring to the statement made by the author that equation [2] was correct for any definite temperature, I would like to point out a question of premise. The statement is correct, but in making a test on a pipe line there are no definite temperatures; there is a certain temperature at one end of the line, and a certain temperature at the other end of the line, and I think more stress should be given to the temperatures between the two. It is not safe to use the average; it is much safer to use an integrated value, which can be obtained with a planimeter. The fact that the line goes through a variable country, with different soil conditions and different rate of radiation, is the problem that is confronting the engineer working in difficult country, or country subject to overflow, and it is very difficult to estimate what temperature you are going to get.

Another problem which is perhaps of as much importance as the question here, is to predict the temperature at the end of the line. I have been working particularly on long pipe lines, for instance, where there are a series of four or five pumping stations pumping oil over a mountain range and then a long drop, say a 4000 or 5000 ft. to the seaboard, and the problem is to calculate the temperature gradient; we know the temperature at the initial point and wish to calculate the temperature at the terminal, so we can determine between what limits to take the viscosity curve illustrated in Fig. 1, and thus calculate the capacity of the line. Satisfactory equations have been worked out and partially checked with observed data.

In regard to the matter mentioned by Mr. Meredith, it seems extraordinary that such a condition should occur where pumping stations are operating at say one-third speed, but such actually is the case; and it is due to the loss of heat as can be readily seen by examining the temperature viscosity curves. The heat lost is proportional to the temperature and surface of the pipe, so when the velocity is low, the heat losses being the same, the oil rapidly cools, increasing in viscosity and friction until the total head due to friction is greater than when the velocity is higher when there is more oil passing to contribute heat to make up the heat losses.

A. C. McLaughlin[1]. From the standpoint of an operating oil man, it has always seemed to me that the engineer, in approaching the question of the transportation of oil through

[1] Superintendent of Operations, Kern Trading & Oil Co., San Francisco, Cal.

pipe lines, is too much inclined to take as his point of departure the transportation or pumping of water through pipe lines, the laws of which are well known. The transportation of oil is an altogether different problem. In the first place, ordinary crude oil is not a simple homogeneous liquid such as is water, but is a very complex substance, composed of compounds of carbon and hydrogen, which in themselves are simple, but which exist in petroleum in almost bewildering number. In crude oil we find something like eight normal series of hydrocarbons, each series being represented by a large number of compounds differing slightly from each other in physical characteristics. In addition to these ordinary hydrocarbons in petroleum, which we may consider as the essential constituents, there are a great many impurities in the form of sulphur compounds and nitrogen compounds. These impurities are in such large proportions at times as profoundly to influence the physical characteristics of crude oil. For example, in some California crude oils as much as 20 per cent of the volume of the crude oil consists of nitrogen compounds.

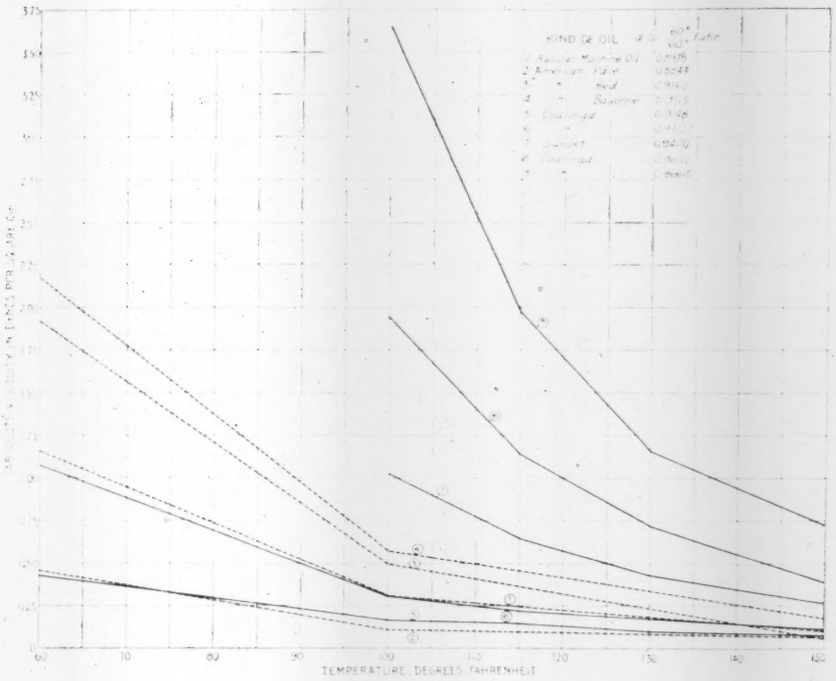

Fig. 3 Variation in Absolute Viscosity, in Dynes per Sq. Cm. with Characteristic California Crude Oils

Since each series of hydrocarbons is composed of members differing but slightly from each other in physical characteristics, the viscosity, boiling point, specific gravity, etc., and since each series differs in the same characteristics from each other series, it follows that rarely two samples of crude oil are precisely alike. It also follows that if one is to predict with accuracy the precise actions of a given crude oil under given conditions of pressure and temperature, it is necessary that he know the constitution of the crude oil and the physical characteristics of each of its components, which, of course, is impracticable. Therefore the practical pipe line man attempts, in so far as possible, to obtain a mixture of a large number of crudes, since it is only by getting such a mixture that he can obtain even approximately constant physical characteristics. On the other hand, he is limited in his mixing crude oils by the fact that different crude oils have different values and must be kept separate. In general, however, it is the practice of the pipe line companies to mix their crudes as much as commercial requirements will allow.

Furthermore, examination into the chemical constitution of crude oil has shown that instead of dealing with a homogeneous fluid like water, we are dealing with a solution of a large number of solid substances in an equally large number of liquids. For bringing out the result of this feature, I have prepared a number of curves, Fig. 3, showing the absolute viscosity in dynes per square centimeter of a number of characteristic California crude oils varying in gravity from 14.9 deg. Bé. to about 23 deg. Bé. An inspection of these curves shows that above a certain temperature each crude oil has a fairly constant viscosity, but that at that certain temperature the viscosity changes very rapidly with drop in temperature. This is explained by the fact that above the given temperature all of the constituents of the crude oil are liquids and the mass behaves as a liquid of approximately constant viscosity. At this certain temperature, which we may call the critical temperature, the solid components begin to segregate from the mass of the liquid and the viscosity of the oil begins to change with great rapidity. The result of this is that the practical pipe line man in pumping California oil tends more and more to keep the crude above this critical temperature, as it is only above that temperature that he can figure with any degree of accuracy. It would therefore seem that successful pumping of California oil will be brought about by successful methods of heating and successful methods of insulating the lines.

It is observed in pumping hot crude oil through pipe lines that the temperature falls with comparative rapidity during the first few miles of its passage through the line, and that the rate of fall of temperature changes very suddenly and the loss of heat is comparatively slow for the balance of the distance into the next station. The explanation of this action is to be found, I believe, in the nature of the crude oil. In the first few miles of the pumping, the crude is above its critical temperature and acts approximately as a homogeneous fluid. About 3 to 5 miles from the initial station the critical temperature is reached, the heavy hydrocarbons begin to segregate and form a coating on the inside of the pipe which protects the balance of the crude oil into the next station. Another factor to be taken into consideration is the specific heat of crude oil, which is only 0.45 as compared with water as unity. This means that for a given loss of heat, the crude oil will drop twice as fast in temperature as water would.

Another factor which comes in is the matter of mixture of

oils in pipe lines, which is a matter that has recently aroused considerable interest on account of the so-called Common Carrier Pipe Line bill. In the case of eastern crudes (Pennsylvania crudes and other light oils), where the heavy hydrocarbons are carried in solution at ordinary temperatures, it has been found that crude oils mix or contaminate each other in passing through a pipe line in plugs, to the extent of about 10 per cent of the total capacity of the line. This was worked out by Professor Shoter of Cornell University during the Standard Oil Company litigation. Now in California crude oil, where are those heavy hydracarbons condensing or segregating on the outside of the pipe line, we naturally get a very much greater mixture than in Pennsylvania. In fact, nobody knows how great it is; but no doubt it would be a very important feature in pumping batches of oil through pipe lines.

R. P. McLaughlin.[1] The curves in Fig. 4, showing the relation of viscosity and gravity of crude California petroleum, are presented with the idea that they may call attention to some points that have not been commonly recognized. Development of the oil industry in this state has been so rapid that most men actively engaged in it have had too little time to stop and summarize. Too frequently a few observations have been the basis of statements that no general rule could be formulated.

Arthur F. L. Bell.[2] There is a very notable difference in the viscosity of oil in different fields, especially the Santa Barbara field. The Santa Barbara oils of the same gravity show a marked increase in viscosity over the oils of the valley; and my experience, from tests I made, was that the oils from Maricopa had the least viscosity of any oil I tried.

TABLE 1

Oil District	Average Data, No. Samples Used	Gravity, (Beaumé), Deg.	Viscosity, Using Egler Viscometer at 20 Deg. Cent., Seconds
Kern.....	40	15.36	915
Midway...	29	16.34	518
Sunset....	25	14.37	527
McKitt...	26	16.37	200
Coalinga...	62	17.32	341

Roughtly speaking, tests of 12 gravity Maricopa oil had no greater viscosity than 14 gravity Kern oil. Bulletin No. 19 of the Bureau of Mines gives the data presented in Table 1.

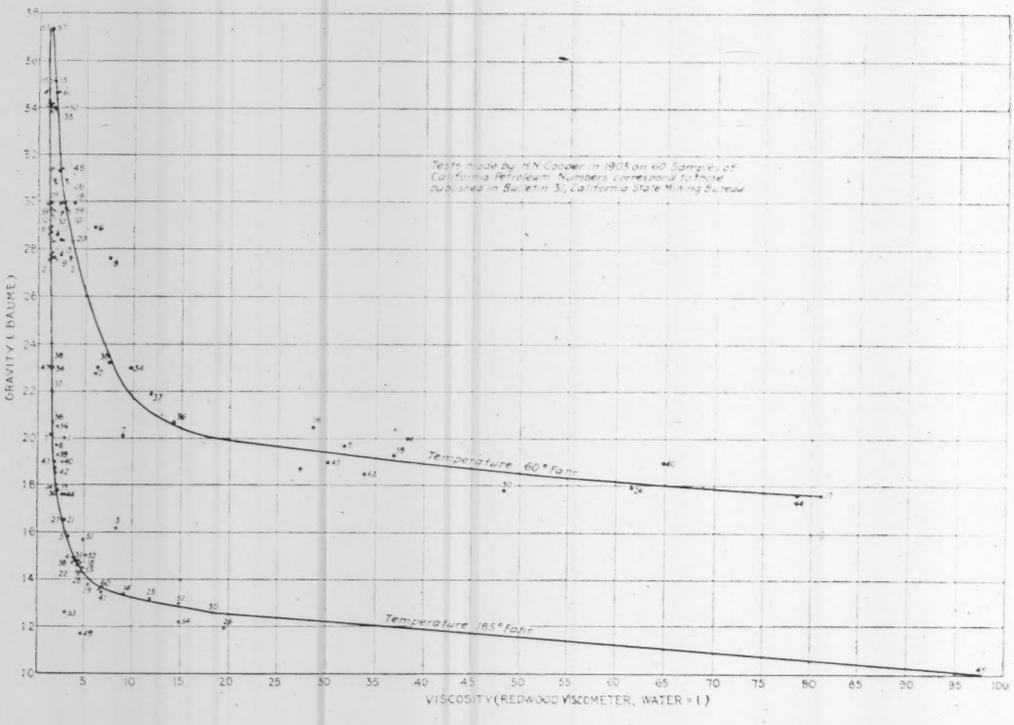

Fig. 4 Curves showing Relations between Gravity and Viscosity of California Crude Petroleum

A. C. McLaughlin. Crude oils vary in viscosity, depending on the composition of the crude. In a paraffin crude oil, the drop in viscosity with the temperature is very much less than it is with the so-called asphalt crude oil. Of course there is no such thing as an asphalt and a paraffin crude oil except as concerns the end members of a series. All crude oils are to a certain extent paraffin crude oils, and all paraffin crude oils are to a certain extent asphalt crude oils. For example, we have the Pennsylvania characteristic at one end and the California at the other. But it is a fact that paraffin hydrocarbons decrease in viscosity with temperature very much more rapidly than the so-called saturated hydrocarbons, which are composed of those asphalt crudes. Most of those curves plotted are not curves of viscosity, but time of flow; and in examining them it will be found that they are very different looking curves from the true viscosity curves when the density of the oil is eliminated.

[1] Petroleum Dept., California State Mining Bureau, San Francisco, Cal.

[2] Chief Engineer, Associated Oil Company.

H. T. Cory. In regard to Mr. McLaughlin's comment that what is called viscosity is not the true coefficient of viscosity, doubtless the men in the oilfields are using a coefficient that they think better serves their purpose than the true coefficient of viscosity. The Beaumé reading and the specific gravity are both intended to express a certain physical characteristic of oil; and are simply two ways of expressing that characteristic. In this particular case these two ways are sufficiently distinct. However, this "viscosity" which has been used in the discussion here, and the real coefficient of viscosity, are so entirely different that the use of the term "viscosity" seems to me very unfortunate. Apparently some of the oil terminology is pretty far from being standardized.

Robert Sibley. The standardizing of some of the units of measurement that are utilized, for instance, the measurement of gravity, the Beaumé scale, is a point that concerns our San Francisco Section. Recently, the Standard Oil Company issued Bulletin No. 4, in which was described a conversion of specific gravity readings into the Beaumé scale, and *vice versa;* and also was given an entirely different formula than is found in Kent's Mechanical Pocket Book and that adopted by the United States Bureau of Mines. In other words, there is evidently a conflict in the adoption of an empirical relationship such as the Beaumé scale; and it would seem to be one function of this Society, as long as we are concerned largely with the manipulation of crude oil, especially its use in the industries, to add its weight somewhat in standardizing those relationships if possible.

R. P. McLaughlin. It seems to me the relation which exists between the viscosity and the gravity of California crude oils might help to standardize some of these discussions. I have plotted a number of viscosity tests in the form of curves and there seems to be a definite relation between viscosity and gravity. The data for these curves are published in Bulletin No. 31 of the California State Mining Bureau and cover in the neighborhood of 60 different samples of oil from all parts of the state. The temperature viscosity curves are for two different temperatures, namely, 60 deg. and 185 deg. fahr.

H. W. Crozier. I would like to ask Mr. McLaughlin for further information about those curves. My experience is entirely at variance with his results and, while we have always known that the viscosity was in some way related to the gravity, so many exceptions have come to our notice that, in exact work, we do not consider that knowledge of the gravity of an oil sample gives us very much information about what its performance will be in a pipe line.

R. P. McLaughlin. The curves are, in general, correct and show the relation between gravity and viscosity at the definite temperatures used, but, as Mr. Crozier stated, there are a number of samples which differ widely from the average shown by the curve, and I would particularly call attention to samples Nos. 40 and 56, which have viscosities over twice that given by the reading from the curve, while samples Nos. 42 and 50 are very much below the readings of the curve. Also in regard to some of the oils from the Kern and Los Angeles fields of about 12 and 13 gravity, there are four samples: 53, 54, 26 and 49, which depart widely from the 185 deg. curve. These curves may be used in a general way for the determination of the probabilities, but, as Mr. Crozier has pointed out, it is advisable to sample and test the oils before making a prediction as to what they will do in a pipe line, and it will be noted that many of the exceptions depart widely from the average condition represented by the curve, which is, of course, a generalization.

PRESENT TENDENCIES IN RAILROAD WORK

PAPERS PRESENTED AT A JOINT MEETING IN BOSTON

THE MODERN LOCOMOTIVE

By Henry Bartlett, Boston, Mass.

Member of the Society

Twenty years ago the express passenger engine was of the eight-wheel type with 18 x 24 in. cylinders, a 58 in. boiler carrying 160-lb. of steam, a grate area of 19 sq. ft., a tractive power of 15,300 lb. and a weight in working order of about 50 tons. Since that time larger eight-wheel passenger engines have been built, then the Atlantic type of locomotive, and now the Pacific type has been reached as the standard express locomotive on many railroads. The standard Pacific type express locomotive of the Boston and Maine Railroad has 22 x 28 in. cylinders, a 68 in. boiler carrying 200 lbs. of steam, a grate area of 53.2 sq. ft., a tractive power of 31,600 lb. and a weight in working order of 235,000 lb. These locomotives have also many improvements, including a superheater, piston-valves, Walschaert valve-gear, a brick arch, pneumatically operated fire-door, flexible stay bolts, extended use of cast-steel, a design of trailing truck permitting the use of a deep wide fire-box.

These engines show an increase of 83 per cent in capacity and at the same time an increase of 80 per cent in weight over the standard of twenty years ago. This increase in weight in about the same proportion as the power may perhaps suggest a lack of refinement in detail, but upon investigation it will be seen that this apparent disparity does not actually exist as one of the most characteristic improvements in locomotive design has been the introduction of the trailing truck which makes it possible to obtain ample heating surface and larger grate area; this enables the locomotive to deliver its rated tractive power under all service conditions and to do it with the consumption of less fuel.

Abstracts of papers presented at a joint meeting held at Boston on February 4 by the American Society of Mechanical Engineers, the Boston Society of Civil Engineers and the American Institute of Electrical Engineers.

Local conditions have developed larger passenger engines on some other roads, and the introduction of heavier steel cars will require still greater power to handle them. An example is the famous No. 999 on the New York Central Railroad with which was inaugurated the Empire State Express at the time of the Chicago Exposition, and in comparison with this the Pacific Type engine that now handles the Twentieth Century Limited between New York and Chicago. In these engines, the increase of 100 per cent in tractive power and 118 per cent in weight is a mute testimony to the rapid growth in weight of rolling stock as well as in passenger traffic. An interesting feature of the old No. 999 locomotive was the water table extending the full length and width inside the fire box as a substitute brick arch; there can be no doubt but that the increased heating surface and circulation obtained in this way was an important factor in the phenomenal success of that engine, but today we are obtaining similar results in an easier way with the brick arch supported on water tubes.

The development of twenty years on the Rock Island Railroad has been to the use of the mountain type of locomotive, the latter being designed to haul heavy passenger trains over 1 per cent grade at moderate speeds and yet be capable of attaining speed of from 50 to 60 miles per hour on levels. The increase in tractive power here is 138 per cent and in weight 156 per cent. One of the best examples of modern locomotive design is a locomotive that was built by the American Locomotive Company for the Pennsylvania Railroad for testing out purposes. This locomotive which is of the Pacific type, has been given a long try-out at the testing plant at Altoona, at speeds ranging up to 85 miles per hour. Notwithstanding the immense power and weight of this engine, it has delivered a horse power hour on 16.4 lb. of water and 2.66 lb. of coal, establishing a record in this respect; the best performance of twenty years ago was a horse power hour on about 27 lb. of water and 4 lb. of coal. This remarkable locomotive showed an evaporation of 6500 gal. of water per hour and develops a draft in front of the diaphragm of 19.6 in. of water. The maximum coal consumption in these tests was 9700 lb. (4.8 tons) per hour, which was accomplished with stoker firing; in this manner about 50 per cent greater boiler capacity was obtained than would have been possible with hand firing.

Twenty years ago, ten-wheel locomotives were in common use for freight service. The standard freight engines on the Boston & Maine Railroad at that time, had 19 x 26 in. cylinders, a 58 in. boiler, carrying 150 lb. of steam, a grate area of 19.5 sq. feet, a tractive power of 20,600 lb., and a weight in working order of 116,000 lb. The present standard freight engine of this road is of the consolidation type, with 24 x 30 in. cylinders, a 68 in. boiler, carrying 180 lb. of steam, a grate area of 53.5 sq. feet, a tractive power of 43,400 lb. and a weight in working order of 210,500 lbs. This engine has also the latest features of design such as superheater, Walschaert valve gear, piston valves, a brick arch, pneumatic fire-door opener, etc., the increase in this class of engines being 90 per cent in power and 81 per cent in weight.

The transportation of freight is the most important problem that the majority of railroads have to consider, as it produces the largest part of their gross revenue and consumes the greatest proportion of their operating expenses. In considering the best type of locomotives we are confronted with a great variety of requirements which must be met in conducting this traffic. The consolidation type is giving good service where traffic conditions are suited to its limitations, that is, low or medium speed; as a type, it carries a greater proportion of weight on its driving wheels than any other road-engine, and in that respect is the most logical type to select for the above mentioned class of traffic. As the demand came for more rapid movement of freight trains, more powerful consolidations with larger driving wheels were developed, but they did not fill the requirements as expected because of lack of boiler capacity to furnish steam at the higher speed, and also the fact that the larger driving wheels had restricted the depth of the fire-box to such an extent that a large part of the heating surface was valueless. This has resulted in the development of what is called the Mikado type of engine which is really a consolidation with a trailing truck which permits the application of a boiler large enough to furnish steam for the maximum requirements and at the same time give ample room for a fire-box of the requisite area and depth. This type is the latest word as a fast freight locomotive, a large number having been built in the last year or two.

The Mallet type or articulated locomotive has made it possible for many roads to increase greatly the tonnage over a division on which a short heavy grade absolutely limits the train load to a fraction of what could be hauled over the remainder of the division and where it is too expensive to reduce the grade. Some enormous Mallet locomotives have been built of recent years, one being tested out by the Pennsylvania Railroad which has evaporated 71,000 lb. of water and consumes 15,000 lb. of fuel per hour; in this engine both sets of cylinders are simple, whereas usually Mallet locomotives are of the compound type. The fuel consumed at the above rate was 86 per cent of two consolidation locomotives of equal aggregate power.

The greatest advance in locomotive development in recent years has been the perfection and application of the high-temperature superheater. Although introduced extensively only a little over two years ago, it has proved its value so undoubtedly that today there are over 7,000 locomotives with superheaters. This device makes it possible to reduce very greatly the

amount of fuel consumed and what is fully as important also, offers a method of obtaining power without exceeding the capacity of the fireman. Among the many attempts that have been made to improve and insure complete combustion, the Gaines fire-box and combusting chamber is an example; in this device, a large volume of heated air is introduced into the fire-box through tuyeres in the vertical wall which materially improves combustion. An important advantage of this type of fire-box is the means it offers of getting ample depth above the grate in designs with shallow throat sheets.

TRACK

By A. B. Corthell,[1] Boston, Mass.

Non-Member

The first steel rails made in this country were rolled at Danville, Pa., in 1845. Other rollings were made in the same year by the Boston Iron Works, the Trenton Iron Works, the New England Iron Co., and the Phoenix Iron Co. The first Bessemer rail made in the United States was rolled in Chicago in May, 1865; the first Bessemer steel rails to be produced on a commercial order, were rolled in Jamestown, in August 1867. The introduction of the Bessemer process thoroughly revolutionized the art of rail manufacturing and the ultimate effect on railway building and commercial development of our country can hardly be over-estimated.

Attempts were made about 1870 to roll a combination rail with steel head and iron web and base, but the rapid reduction in price of all-steel rails rendered this process of no economic value, for while steel rails in 1872 sold for $140 per ton, in 1882 the price had dropped to $35 per ton. This cheaper production made possible the heavier rail of recent years, also the larger locomotives, greater capacity cars, and correspondingly greater economy in railroad operations. It is interesting to note in this connection that there seems to have been a fixed relation between the weight of rail in pounds per yard and the weight of locomotives in tons, for when we had 60 lb. rails in general use, we had 60 ton locomotives, and with the 100 lb. rail, came 100 ton locomotives; roughly speaking in 70 years the weight of rails has increased 70 lb. or 1 pound per year.

Not many years ago the designing of rail sections had become a fad. Most engineers were called upon to get up a new standard design and nearly all roads had their own standard sections. As a matter of record, the rail mills at one time had no less than 188 different patterns and 119 patterns of 37 different weights per yard. The situation was investigated by the American Society of Civil Engineers and in 1893, after more than three years deliberation, the Society reported upon standard sections for rail from 40 to 100 pounds varying in weight in 5 lb. increments. This report was accepted by the Society and recommended to the railroads for adoption during the year 1901. Rails of the above type of sections constituted fully 75 per cent of all the rails rolled in American mills.

In 1901 the report of the American Railway Association recommending the use of 33 ft. rails was adopted. In October 1907, a preliminary report was submitted accompanied by two series of proposed standard rail sections and in 1908 the report recommended types A and B. Since October 1907 several mills have rolled rails substantially in accord with the new sections, both A and B, and it has been demonstrated that these sections can be finished in the mill at a lower temperature than the A.S.C.E. sections. A finer grained and better wearing rail should be secured. However, great care must be exercised in the mills to see that the rails are actually rolled at the lower temperature.

During the year 1913 there has been laid on the Boston and Maine Railroad, 500 tons of 85 lb. frictionless rails in curves of 5½ deg. and over, with which it is hoped to lessen materially the flange wear on high rails which on sharp curves is always considerable. Actual experiment shows that curve resistance is a great deal lessened by the use of this rail. The theory offered for the action of the so-called frictionless rail is based on the means that it offers the outer wheel on each axle to become dominant over the inner one, and the inner wheel to slide laterally to release the outer wheel flanges as they are forced against the outer rail. The outer wheel is traversing a greater distance through a curve than the inner one but is making the same number of revolutions. On this account, a compensating slide of the outer wheel or a spin of the inner one must occur. The frictionless rail allows this necessary spin to occur at the inside rail.

No subject concerned with track appliances has been more discussed than that of the joint fastening. The evolution of joint fastenings has advanced through three stages; first, the chair which maintains the ends of the rail in alignment and serves as a bearing; second, the fish plate which afforded the rail some support under the head but greatly improved the matter by stiffening the junction of the rails vertically, and third, the angle bar which combines the features of the fish plate and flange and effected a great improvement in both the vertical and horizontal stiffness of joint fastening; the plain angle bar is very simple, easily applied and cheap in first cost.

The conditions which bear some relation to the wear of splice bars are the extent of bearing surface and the hardness of the metal. In the new 85 lb. rails and smaller sizes, the question arises whether the plain angle bar meets with the ideal requirements of the splice bar in the two important respects, strength, and the wear in the immediate vicinity of the joint which

[1] Chief Engineer, Boston & Maine RR.

affects the close union of the parts. We know that angle bars are not strong enough because they bend and take a permanent set in service, and occasionally one breaks. The supported joints which we have had in use are the Fisher, the Continuous and the Weber joints.

For bolts to fasten the joints to the rails, the most efficient are those having the so-called grip thread. This bolt is made of a soft steel and the threads are cold pressed in a manner to upset the metal so as to reduce the diameter of the bolt but slightly at the bottom of the thread. The threads are ratchet shape and under cut 5 deg. on the bearing side. In the nut the bearing side of the thread is at right angles to the axis of the aperture, so that when it is screwed tight against the splice bar the threads of the bolt give to the extent of which they are undercut and the metal will be pushed completely to the outer recesses of the nut threads, so as to hold the nut against turning off. The nut is square with the corners chamfered next to the wearing surface which gives an approximately circular bearing. On the bearing side the nut is recessed the depth of a thread and to a diameter somewhat larger than that of the threaded bolt, thus housing and protecting the many threads against injury by the chafing on the splice bar.

The first tie-plates were used to prevent rails from cutting into and destroying the ties. Gradual development has added other features such as the top shoulder, spike hole, bottom claws and ribs, all tending to make the tie-plate not only a tie protection but a more valuable rail brace. Economy of material compels a minimum of weight consistent with strength and one of the most important considerations is to obtain a tie-plate which will unite firmly with the tie; otherwise it will pound the tie and wear it under rail vibration and afford no lateral resistance to the spreading of the rails. As such a requirement cannot be had by a plate with a smooth underside, practically all tie-plates are now made with under projections in the shape of claws which enter the wood crosswise of the grain or of the flanged or rib type which enter the wood longitudinally with the grain. In the former case the lateral displacement of the plate is resisted by an abutment against an end section of the fibres. The standard Boston and Maine tie-plate has four flanges which enter the grain of the tie longitudinally, running the width of the plate. The latest tie-plate shows the two longitudinal flanges and two smaller transverse flanges on the bottom, a heavier shoulder and a better portioning of material.

Wooden ties have been almost universally used by the railroads of this country and are still used as best practice. Steel ties and ties of concrete construction have been made and are used to some extent with varying success. For wooden ties, the hard wood tie of oak, chestnut and hard pine are used mostly for main line traffic and the softer woods such as cedar, for branch lines of light service. The standard Boston and Maine tie is 6 in. thick by 8 in. wide and 8 ft. long. The average life of a chestnut tie is seven years, and hard pine ties eleven years. The life of a tie can be lengthened by the use of tie-plates and preservatives.

I can see no radical change in the present track materials or methods in the immediate future. The rail may be heavier and more spikes, tie-plates and braces added, but the general design will be the same. The changes in turnouts and yards will be most marked; longer switch leads, wider spacings of track, heavier rail and more careful maintenance are already necessary in a great number of our yards due to the increased loads in power and rolling stock. In the Pennsylvania Terminal in New York City, we find part of the tracks laid on stone ballast and some part on a solid concrete base, with creosoted ties bedded therein and anchored by bolts to the concrete.

ELECTRICAL EQUIPMENT

By Frederic D. Hall,[1] Boston, Mass.

Non-Member

SYNOPSIS OF PAPER

The author showed slides illustrating types of later electric locomotives and the catenary construction for both A.C. and D.C. operation. The present slow growth should not be taken as a sign of lessened determination or activity. The installations already made for special requirements, while handling traffic in a manner impossible by steam, are short and disconnected, thereby not permitting realization of full economies. No statement that installations are other than successful can be regarded seriously, for railway managers are too conservative and too much occupied with detail required of them to listen readily to radically new methods of operation. The present attitude of manufacturers, each exploiting his own system, is confusing to railway men, and detrimental to their common interests; designing engineers are not very far apart in their convictions. A standardized system of distribution must be worked out before an argument strong enough to carry conviction can be presented, and the burden of proof must rest on the manufacturers. Railway managers are not fair in their consideration of electrification, since they compare the cost of an entire electrification with that of a few steam locomotives from time to time without sufficient regard for future requirements and without considering the various expensive changes in road bed, bridges, engine houses, turntables, new shops and tool equipments, etc., made necessary by the heavier power, not only a heavy capital charge but an ever increasing operating cost, not charged to cost of new locomotives but passed by merely as improvements to property.

[1] Elec. Engr., Boston & Maine RR.

THE SPRING MEETING

THE Spring Meeting at St. Paul-Minneapolis, the first meeting of the Society to be held in the "Twin Cities," was a decided success. The attendance was unexpectedly large, influenced probably as much by the natural local attractions as by the program of professional papers. The Local Committee, consisting of Max Toltz, Chairman, Chas. L. Pillsbury, Vice-Chairman, E. J. Heinen, Secretary, Paul Doty and W. H. Kavanaugh, had made extensive provision for the comfort and entertainment of the visitors, and the numerous social features, with the various excursions to plants of interest in the vicinity, were thoroughly enjoyed.

The meetings were held from June 16 to 19, with headquarters at the St. Paul Hotel in St. Paul, there being 121 members registered and 279 guests, a total of 400. The professional meetings were held in the ball room of the hotel, with the exception of the Thursday forenoon session, which was held in the Engineering Building of the University of Minnesota in Minneapolis. The usual Friday morning session was replaced by technical excursions which, in line with the present practice of the Committee on Meetings to provide increased opportunity for social attractions at the Spring Meeting, did much to add to the pleasure of the meeting. Interest in the meeting was also enhanced by the provision by the local committee of several papers of local interest.

The headquarters were opened in the hotel for the registration of members at noon on Tuesday. At four o'clock, the elaborately equipped special train arrived from Chicago over the Chicago, Burlington & Quincy Railroad, and was met at the Union Depot by special street cars that conveyed the party to the headquarters. About 115 members and guests came on this train and reported an enjoyable trip. Several stops were made en route to view features of interest.

TUESDAY EVENING RECEPTION

At 8:30 in the evening a reception was held, followed by addresses by the Chairman of the local committee, by Governor A. O. Eberhardt, representatives of the city of St. Paul, including the Mayor, and by H. L. Gantt, vice-president of the Society, who, in the absence of the President, James Hartness, replied for the visitors. Mr. Gantt spoke of certain duties and responsibilities which will undoubtedly fall upon the shoulders of engineers. In some quarters the engineer has already assumed these responsibilities, in others, it has not yet been recognized that such duties belong to the engineer; but inasmuch as they are problems affecting our national welfare and the engineer seems to be the man best fitted to solve them, there is no question but that he will ultimately have to accept the task of their solution.

BUSINESS SESSION

The business session of the Spring Meeting was called to order on Wednesday morning by Vice-President Gantt. As the first order of business, the Secretary announced the membership ballot upon the amendments to the Constitution, proposed a year ago, with respect to the grades of Member and Associate-Member. These amendments were approved and in each case resulted in raising the requirement for membership. Under the new plan one must have reached thirty-two years of age to become a member, and must have been in active practice of his profession for at least ten years and in responsible charge of important work for five years; or if a teacher, equivalent experience is required as professor of engineering in charge of a department. To become an Associate-Member, a candidate must be at least twenty-seven years of age with six years' professional experience and one year in responsible charge of work. With these amendments the Society now ranks with those having the very highest professional requirements.

The Secretary further announced the vote of the tellers on the Code of Ethics published in The Journal for January 1913, by which this was declared to be the code of the Society.

Henry Hess moved that article C 45 of the Constitution be amended by adding to the list of standing committees the Committee on Standardization. This will come up for discussion at the Annual Meeting.

The next subject was the report of the Committee on Standardization of Flanges. This report had previously been approved by the Council with an expression of high appreciation of the work which had been done. The report as presented was the result of conferences of several bodies interested, held at Washington, D. C., in March and in the rooms of the Society in New York in April. At these conferences several changes were made in the schedule as presented for preliminary discussion at the Annual Meeting in December and published in The Journal for January under the title of the "American Standard." The various differences of the several interests had been adjusted satisfactorily with the one exception of the name by which the report should be known. Earnest T. Child and Edward B. Denny spoke for the National Association of Master Steam and Hot Water Fitters in favor of the name "1915 U. S. Standard." As the first report was issued under the name "1912 U. S. Standard" and had become widely known, they felt that it would be advantageous to retain the name, with the date changed. As their organization had initiated the movement for standardization, the continuation of the original name would also be in the nature of a courtesy to them. A. B. Carhart said that orders were

coming to his firm for "U. S. Standard" flanges as a result of the 1912 report, without distinction being made as to the year, and that confusion might arise if the revised report should bear a similar title.

A motion was made and carried that the matter of the name be referred to a committee composed of appointees of each of the societies or bodies interested in this report.

Next followed what proved to be the event of the business meeting, a discussion upon the subject of specifications for steam boilers. The tentative draft of the Committee on Steam Boiler Specifications had been printed and distributed among a large number of engineers so that the work of the committee might be checked up and revised before the report was submitted for general discussion as will be the case at the next Annual Meeting. There had been a meeting at Chicago on the previous Monday attended by representatives of the Association of Steel Manufacturers, the Association of Tubular Boiler Manufacturers and the Boiler Specifications Committee of the Society at which there was discussion with regard to the steel specifications to be embodied in the report. The discussion on Wednesday morning was mainly a continuation of that started at Chicago and the Chairman announced that it would be considered informal only. It led to a motion providing for a meeting at which the organizations, manufacturers and others concerned could appear to present their arguments before the Committee and during the discussion of this the Chairman finally asked those most interested to adjourn to another room so that the resolution could be put into a definite shape and be presented to the meeting at the following session. This was done and at the afternoon session, E. E. Keller, Vice-President, who acted as Chairman at the separate meeting, read the following resolutions:

Resolved that on September 15, 1914, a committee hold in the rooms of The American Society of Mechanical Engineers, 29 West 39th Street, New York, a hearing of all interested and concerned in the preliminary report of the committee appointed to formulate standard specifications for the construction of steam boilers and other pressure vessels and for care of same in service, and that those desiring to participate in the discussion present in writing their criticisms and discussions prior to August 15.

Resolved that in addition to invitations, notification by publication in the technical press be given to the hearing.

The resolutions were adopted after considerable discussion.

PROFESSIONAL SESSIONS

Following the business meeting, the first technical session was held on the subject of Powdered Fuel, which was followed by a topical discussion with several contributions in reply to a set of questions covering a number of items relating to the use of pulverized coal.

Two other technical sessions were held during the meeting, one on Wednesday afternoon, with a series of miscellaneous papers, and one on Thursday morning at the University of Minnesota, when papers by local engineers were presented. These will be reported in The Journal. The following is a list of the papers read:

Pulverized Coal Burning in the Cement Industry, R. C. Carpenter
Pulverized Coal for Steam Making, F. R. Low
An Installation for Powdered Coal Fuel in Industrial Furnaces, Wm. Dalton and W. S. Quigley
Industrial Service Work in Engineering Schools, J. W. Roe
Classification and Heating Value of American Coals, Wm. Kent
The Railroad Track Scale, W. Wallace Boyd
Gear Testing Machine, Wilfred Lewis
A Flow Metering Appliance, A. M. Levin
Power Development at the High Dam Between Minneapolis and St. Paul, Adolph F. Meyer
The Handling of Coal at the Head of the Great Lakes, G. H. Hutchinson
Minneapolis Flour Milling, Charles A. Lang

CONFERENCE LUNCHEON

Following the adjournment of the Wednesday morning session, June 17, a conference luncheon was tendered by the members of the Council to representatives of local committees and sections in attendance at the meeting. The Council was represented by Messrs. Gantt, Reist, Keller, Davidson, Jackson, Hess, Hunter, and Secretary Rice, and 13 representatives of the Minnesota section and other local committees, the luncheon being laid for 21 covers.

Opportunity was here offered for a general discussion of local committee and section matters, and Secretary Rice pointed out the great opportunity for development of the activities of the Society through the local section work, giving an account of the present state of this branch of the Society's affairs. He also gave an interesting account of publication matters and other features of general interest in connection with the work at the headquarters in New York.

WEDNESDAY EVENING LECTURE

On Wednesday evening John Hearding, superintendent of the Oliver Iron Mining Company, Duluth, delivered a lecture on Ore Handling, in which he showed all phases of iron mining work on the Mesaba Range from the rough mining methods in the pit to the shipping of the ore and its chemical analysis. The speaker illustrated his remarks with moving pictures which showed the processes in the most graphic manner, including the steam shovels at work, the various methods of mining, especially the open method which is the one employed with the steam shovel, and finally the shipment of the ore itself. Sampling of the ore was shown and also the weighing of each car automatically as the train passes. The rapidity with which a vessel may be loaded with the ore from the stock bins into which it is delivered from the train was also shown.

There was a large attendance at this lecture, which was one of the most successful events of the convention.

SESSION AT THE UNIVERSITY OF MINNESOTA

The meeting of Thursday morning was held in the main engineering building of the University of Minnesota, in Minneapolis, and was called to order at 10 o'clock by C. L. Pillsbury. Mr. Pillsbury made a few brief introductory remarks in which he spoke of the pride of Minnesota in its university and its achievements. The main engineering building, he said, is in reality the nucleus of a group of new and very fine engineering buildings which are to surround it on the campus, constituting the College of Engineering. The Experimental Engineering Building has already been constructed, and the Chemistry Building, the third of the group, is now under way, and is expected to be when completed one of the finest in the world in point of equipment and design for the purpose for which it is intended. A new Electrical Building and a new Mechanical Engineering Building will be the next in order.

Mr. Pillsbury then introduced the Hon. Fred B. Snyder, Senator, and Regent of the University. Mr. Snyder briefly recounted the history of the State, from its beginning as French territory to its entrance into the Union as a full-fledged State. He said that he was born in the first house built on the other side of the Mississippi River and was a baby in his mother's arms at a time when it was not infrequent to see Indian faces peering in at the window. If so much can be done in a community in fifty years, what will the next half century have to show in the way of progress? He spoke further of the architectural plans of the University and of how in 1863, to liquidate its indebtedness, a committee of citizens voluntarily offered their services to prevent the forced sale recommended by the legislature. He also said that the State owed much to the pioneer New England stock who formed its first colonists.

Prof. H. T. Eddy, Emeritus Dean of the Graduate School of the University, was then introduced. The Engineering College, he said, was unique in the United States, in that the students were almost exclusively drawn from Minnesota, and that during the past twenty years it had grown from almost nothing to a size which places it in competition with other engineering colleges. Several problems have confronted the faculty, among them how its students shall be best fitted for their profession, as a result of which an additional year has been added to the customary four, in which more strictly professional work has been included.

Mr. Snyder was then called upon again to speak of the ownership by the State of certain lands which furnish the University funds, since the University has no endowment, but is entirely dependent upon the legislature for its support. Mr. Snyder said that a fixed rate, 0.23 of a mill, is customarily levied upon the total assessed value of the State, but in addition to this a provision has been incorporated into the State organization that certain fixed lands shall be set aside for the support of education. There are also certain lands which have come by way of grants from the Government which are used for the same purpose. Many of these are mineral lands, which are leased to operating parties, and the royalty derived is devoted to the University.

H. G. Reist, Vice-President, representing the Council, then took the chair and made a few brief remarks on the inspiration such an active community as the Twin Cities afforded to visitors. He had been particularly impressed with the valuable property set aside for park purposes as well as with the beautiful buildings, and with the fine state of preservation of the river banks. On behalf of the Society he thanked the local members for their efforts in arranging for so interesting a program and for their welcome to their community. He then said that he thought the meeting would be interested in the fact that the Society's president, Mr. James Hartness, had been detained from the Convention because Yale was honoring him with the degree of Master of Arts, which required his presence in New Haven. It was moved and seconded by the meeting that the following telegram of congratulation be sent to President Hartness:

The members of The American Society of Mechanical Engineers have learned with great satisfaction of the distinguished honor of the degree of Master of Arts which has been conferred on you by Yale University, and wish to express not only their congratulations to you but that you should have brought such distinction to the profession.

The technical papers of the session were then presented.

At the conclusion of the session a buffet luncheon was served in the Experimental Engineering Building, at which the ladies were also present. The following resolution of thanks was passed at the luncheon:

Whereas, The American Society of Mechanical Engineers, assembled in convention from June 16 to 19, 1914, at St. Paul-Minneapolis, Minnesota, has received a most cordial and spontaneous welcome from the members and friends of the Society in these Twin Cities and vicinity and has enjoyed the results of the tireless efforts and faultless preparation of the local committees, and

Whereas, the visiting members and guests have been the recipients of the delightful entertainment so bountifully provided, and have had the opportunity to visit places of marked technical interest;

Be it Resolved: That on behalf of the Society, visiting members and guests, a vote of thanks be extended to all who have participated in these substantial evidences of friendship and good-will, with the assurance that such a formal resolution as this is but a poor and outward symbol of the deep feeling of gratitude which each visitor personally feels for

the hospitality so generously extended; further, that the Secretary be instructed to extend thanks by written letter, to the local Executive Committee, the Ladies' Committee and the other local committees; and to all individuals and organizations that have contributed to our entertainment including the educational institutions and clubs of the cities; and in special measure to Mr. Gebhard Bohn for the invitation to his home for this afternoon and evening.

RECEPTION AT RESIDENCE OF MR. GEBHARD BOHN

Immediately after luncheon the members and guests were conveyed by special train to the residence of Mr. Gebhard Bohn on Lake Minnetonka, where elaborate preparations had been made for their entertainment. Mr. Bohn's residence, one of the most beautiful on the Lake, has an ideal location on a peninsula which gives it the advantages of an island, while it is nevertheless connected with the main land. The grounds, which are finely laid out, were thrown open to the visitors and everything possible arranged for their enjoyment and comfort. A platform was erected at one end of the grounds for dancing, and entertainment of a professional nature was also provided. Daylight fireworks also delighted the guests, and much amusement was furnished by a silhouette artist who caricatured prominent members of the Society who were present as well as local celebrities. Supper was served about 6 o'clock.

EXCURSIONS

The Local Committee had arranged an attractive list of excursions to inspect industrial developments in the vicinity of St. Paul-Minneapolis and a neat brochure was issued relating to these. Perhaps of first interest was the High Dam across the Mississippi between the two cities, a description of which was given in one of the papers presented, but unfortunately high water in the Mississippi at the time of the Convention endangered the coffer dam and the incompleted structures so that the inspection of the work there could not be made.

Among other public institutions or plants to be visited were the new States Prison at Stillwater, having a mechanical equipment of great magnitude, including not only a central power plant and distribution systems for water, heat, light, etc., but complete manufacturing equipment, signal systems, refrigerating plants, etc. A trip was arranged to the main power plant of the Twin City Rapid Transit Company having twenty-five 550-h.p. boilers and several turbines of large size, besides water power equipment. Other power plants inspected were those of the Consumers Power Company, the St. Paul Gas Light Company and the Minneapolis General Electric Company.

There were also, of course, the great flour mills, located near the Falls of St. Anthony on the east bank of the Mississippi, where within a space of eight square blocks is to be found the largest milling center in the world. In this district are 22 of the 26 mills in operation in the city of Minneapolis, among these being the Washburn-Crosby, Pillsbury, and the North Western Consolidated, with a daily output of 77,000 barrels of flour. The modern and highly efficient character of the machinery employed in the mills is illustrated by the fact that the Washburn-Crosby Company has recently scrapped a power plant costing $30,000 in order to replace it with the most modern equipment.

The industrial plants visited in St. Paul included that of the White Enamel Refrigerator Company, manufacturing house and special refrigerators and the refrigerator equipment for refrigerator cars. There are now about 70,000 of these cars in operation in the United States and Canada and all of the fruit and vegetables raised on the Pacific Coast are transported in them. A second plant of this company, the Northern Insulating Company, is devoted to the manufacture in immense quantities of flax fiber for insulation for refrigerators, the processes of which are unique.

At the American Hoist & Derrick Company, manufacturers of derricks of all descriptions, hoisting engines, electric hoists, locomotive cranes, railroad ditchers, log loaders and wire rope clips, the actual working of a railroad ditcher was shown. Griggs, Cooper & Company, with an equipment for making crackers and candy, the Waldorf Box Board Company, which has a tonnage of about 300 tons per day, and the Crex Carpet Company were also thrown open to visitors.

In Minneapolis, the trips included the Minneapolis Steel & Machinery Company, making a variety of products from steel bridges to the smallest of iron and steel castings. The tractors made by this concern are a departure in farm implements, designed to replace the horse in routine plowing, harrowing and hauling for farm work. Visits were also made to the North Star Woolen Mills and the North Western Knitting Company.

During the convention the ladies were shown about St. Paul and Minneapolis in automobiles and given every opportunity to see the many attractions of the locality. Each guest was presented with a souvenir of the convention, in the form of a small silver coin purse.

DULUTH EXCURSION

After the close of the convention on Friday, about forty members availed themselves of the opportunity to visit the city of Duluth, in response to the invitation of the local members, represented by T. W. Hugo. The visitors were shown the harbor of Duluth by moonlight on Friday evening, and on the following day viewed the large ore-handling apparatus of the city.

THE HANDLING OF COAL AT THE HEAD OF THE GREAT LAKES

BY G H HUTCHINSON,[1] ST. PAUL, MINN.

Non-Member

AN industry of such importance as the handling of coal on the Great Lakes is of interest from an historical as well as a mechanical view point, so that it has seemed well to trace briefly the growth of the traffic and to give step by step the gradual development of the mechanical coal handling devices from the simple beginning to the present elaborate installations.

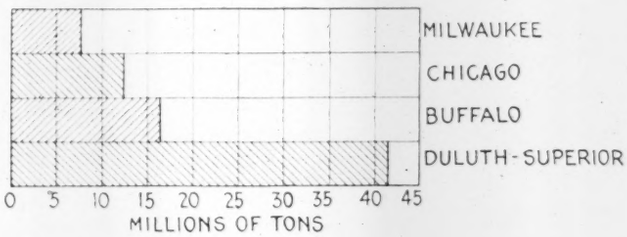

FIG. 1 DIAGRAM SHOWING TONNAGE HANDLED AT TWIN PORTS OF DULUTH-SUPERIOR, CHICAGO, MILWAUKEE AND BUFFALO

greater dispatch and with less confusion and congestion than would be possible by rail. The transportation annually of many million tons of iron ore, copper and coal, of large quantities of manufactured goods, and immense grain crops from tributary territory has resulted in the building up of several natural centers of distribution of considerable magnitude. Among these in order of tonnage are the twin ports of Duluth-Superior, Chicago, Milwaukee and Buffalo, together with a large number of other ports of importance on the lower and upper lakes, Fig. 1. The Great Lakes not only facilitate the distribution to consumers of the products of the mines, the soil and the factory, but make possible the bringing together, at a minimum cost for transportation, of millions of tons of iron ore and coal, a factor of importance in the cheap production of steel.

The Duluth-Superior harbor at the head of the

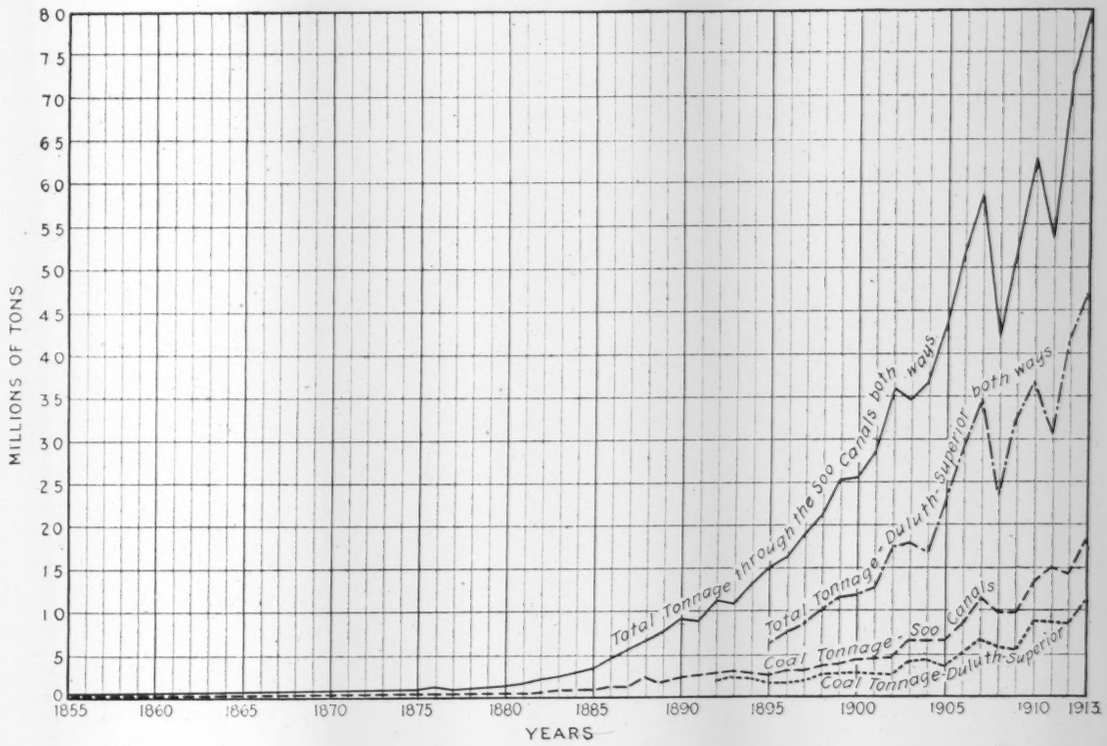

FIG. 2 DIAGRAM SHOWING MARKED INCREASE IN COAL TRADE AND OF LAKE AND RAIL TRAFFIC OF ALL KINDS

The natural waterway formed by the Great Lakes, extending for 1000 miles from Buffalo to the head of the lakes, not only affords cheap transportation, but facilitates the handling of enormous tonnage with

lakes is not only the natural distributing point for the Northwest, but the harbor itself is unsurpassed, considering the essential features of safety, size of harbor, length of shore-line, and the large easily improved area available for dockage.

The shipment of coal to the Northwest by way of the Great Lakes began as far back as 1855, when about

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Presented at the Spring Meeting, St. Paul-Minneapolis, 1914, of The American Society of Mechanical Engineers.

1414 tons passed through the Soo Canal. Little, if any, of this was taken to Duluth and Superior, as the bulk of it went to the copper country in Michigan. It remained for Mr. E. N. Saunders, for many years president of the North Western Fuel Company, to conceive the idea that coal could be easily and cheaply carried by way of the Great Lakes through the Soo to this northwest territory, so much in need of good fuel at reasonable prices. In 1871, he brought up the first cargo of commercial coal ever unloaded in Duluth, and his total shipments during that year were about 3000

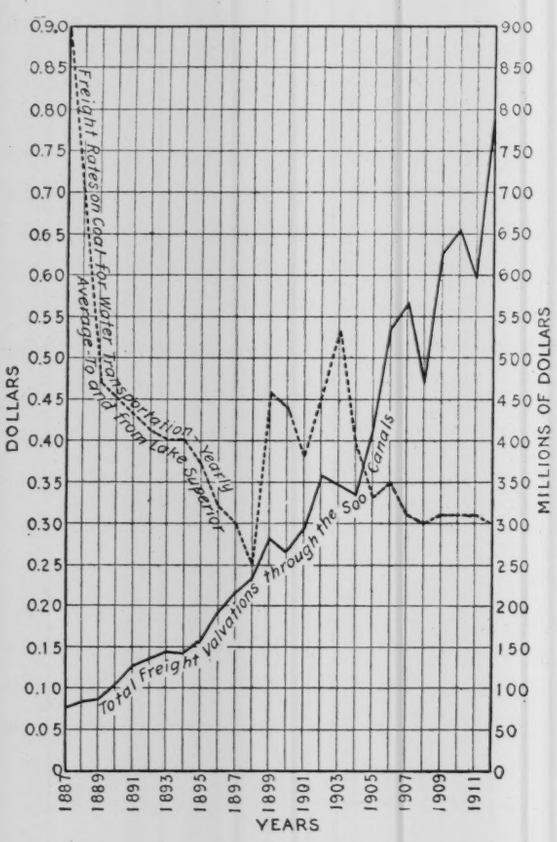


FIG. 3 DIAGRAM SHOWING ESTIMATED ANNUAL VALUATIONS OF FREIGHT PASSING THE SOO FROM 1887 TO 1912

tons. This enterprise was conducted by Mr. Saunders personally for a period of about four years, during which time he had no dock and the coal was unloaded for him, either by the railroad company or by B. S. Russell, a dealer in Duluth. The coal was not stocked, but was reshipped direct by rail. The coal business having grown to somewhat large proportions, the leading coal dealers in St. Paul and Minneapolis formed an association in 1875 to handle coal at Duluth, which in 1877 was organized as the North Western Fuel Company. J. J. Hill was the first president and E. N. Saunders was the general superintendent. The same year, a dock was secured at Duluth and equipped for handling coal.

The increase in tonnage of coal distributed through the Northwest is perhaps the best index of the growth of this section of the country, as coal is used almost exclusively for fuel for domestic and power purposes in the cities, and for locomotive firing, and is also in general use throughout the farming districts. To a limited extent, Eastern coal shipped by lakes is distributed as far west as the Pacific coast. The growth of the coal traffic, which has been very rapid within the past few years, will be further augmented by the general growth of the Northwest, the demands made by the mills of the Minnesota steel plant now nearing completion, and by industries which will be established near the steel plant with a view to the fabrication of its output. The demand for coal will be further increased by the decreasing available supply of wood for fuel.

The kinds of coal transported by water for distribution through the Northwest comprise the various grades of bituminous and anthracite and the several intermediate grades of coal from Pennsylvania, West Virginia, Ohio, Maryland and Kentucky; the bituminous coal from Illinois and Iowa and other states being distributed by rail. Briquets for both power and domestic purposes are also being manufactured in considerable quantities at Superior from anthracite dust and Pocahontas smokeless screenings.

The marked increase in the coal trade, as shown in the diagram in Fig 2 and of lake and rail traffic of all kinds, has called for radical development in the means for lake and rail transportation, and in the harbor and other terminal facilities, and the writer believes that the statement is justified that this demand is being met in an adequate manner. As in other lines of activity, the increased volume of business and the development of facilities are mutually dependent, each making the other necessary and possible. In considering the extensive and highly developed equipment of today required by the large tonnage handled, we should not lose sight of the fact that the primitive methods and equipment may have been as well adapted, all features considered, to the primitive conditions and to handling the tonnage of the early days, as the modern methods and equipment are suited to the present conditions and demands. The dispatch which is required in handling large tonnage, is the chief element justifying as well as demanding present day equipment and facilities, for when ultimate economy is considered, the gain is apparent rather than real, as the cost of actually handling coal is but a small percentage of the total cost, including initial investment, maintenance and other overhead charges. This development of facilities has not been restricted to any individual feature, but has been general and applies to methods of mining, preparation of coal at mines, transportation to lake ports, loading to vessels, water transportation, and the unloading and other handling operations at the receiving docks.

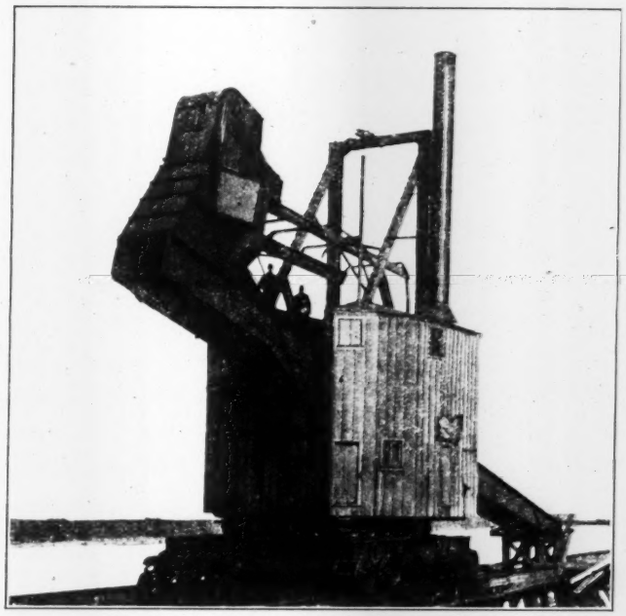


Fig. 4 First End Car Dumper, designed by G. H. Hulett, installed at Ashtabula, Ohio, in 1893

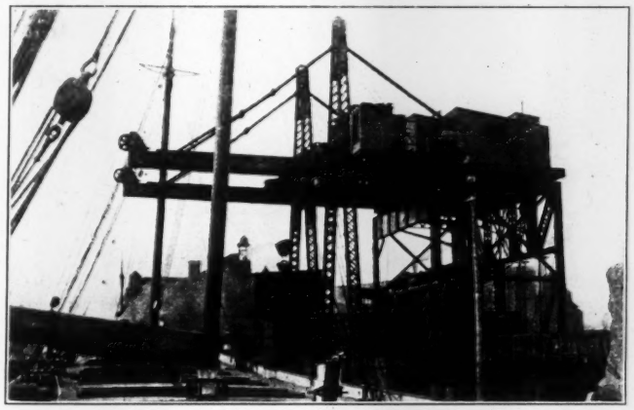


Fig. 5 Hulett Car Dumper, installed on Buffalo, Rochester and Pittsburgh Dock about 1898

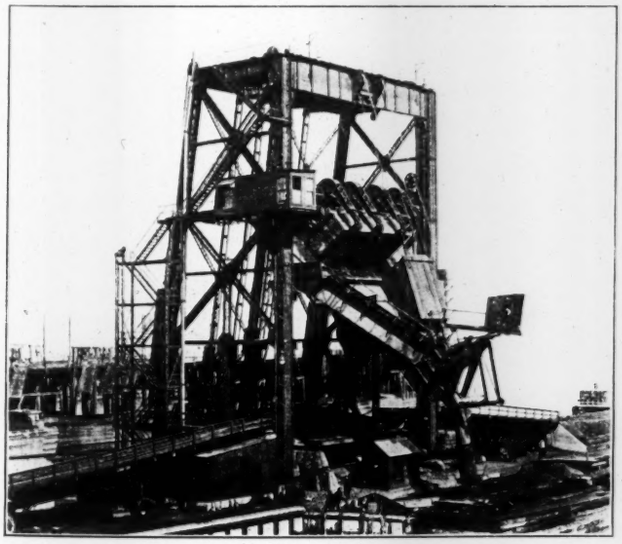


Fig. 6 McMyler Car Dumper, Philadelphia, Pa.

Fig. 7 Thornburg Car Dumper, built by Webster, Camp and Lane, 1896, and installed at Sandusky, Ohio

Fig. 8 Hulett Traversing Car Dumper, built by Wellman-Seaver-Morgan Company for Stocking Iron Ore at Pittsburgh Steel Company's Plant, Monessen, Pa.

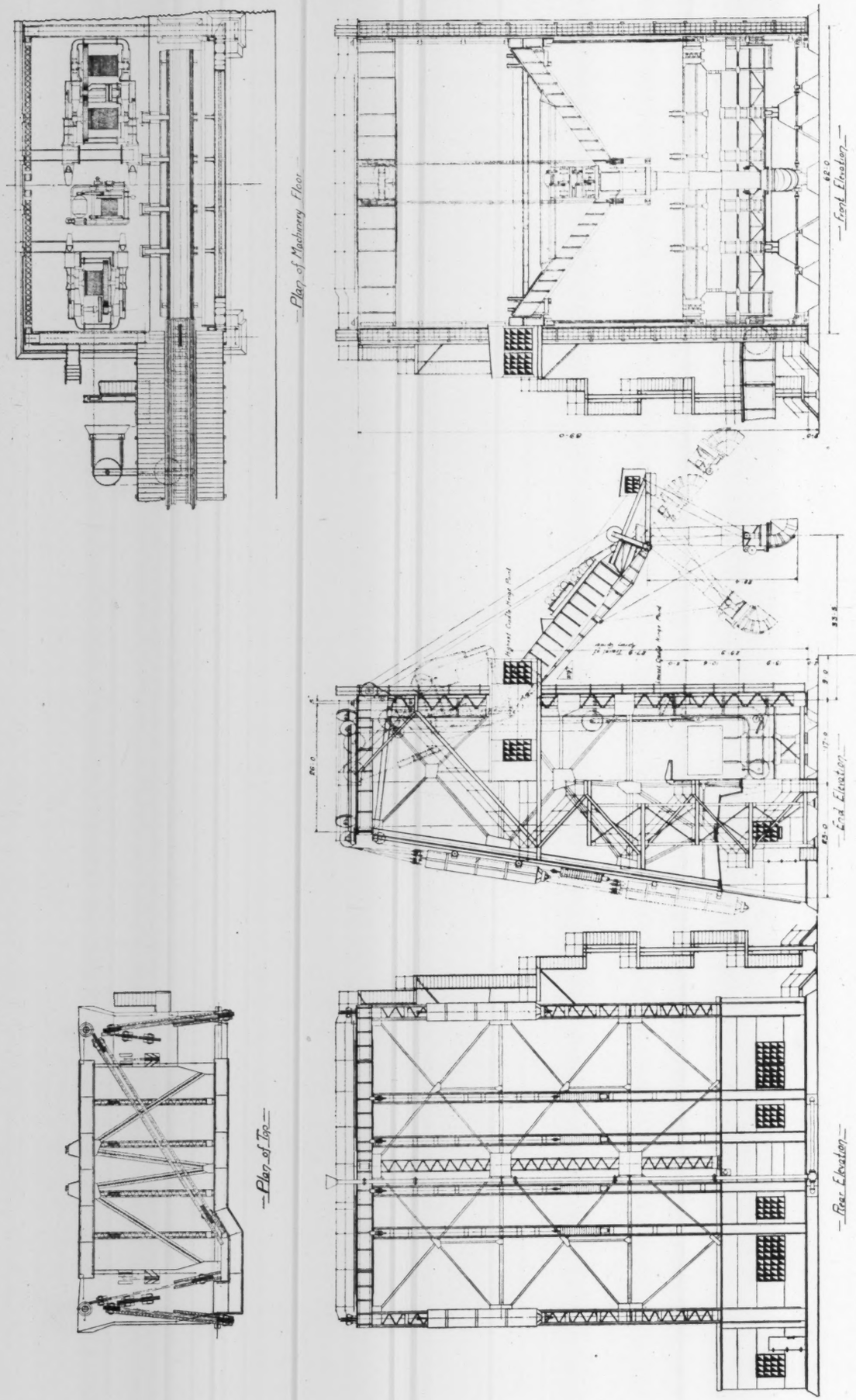


FIG. 9 McMYLER CAR DUMPER BUILT IN 1913 FOR PITTSBURGH AND CONNEAUT DOCK COMPANY

DEVELOPMENT OF TRAFFIC ON THE GREAT LAKES

The degree in which lake vessels have responded to the demand of increasing traffic becomes evident when we consider that 40 years ago the lake craft was made up largely of wooden schooners of 300 tons to 700 tons burden, at which time the total annual tonnage passing through the Soo canal was less than 900,000 tons. In 1912, out of a total of 853 freight carriers, there were 127 vessels between 500 ft. and 600 ft long, having carying capacity of from 9000 to 11,000 tons; and 12 vessels over 600 ft. long, having a carrying capacity of betwen 11,000 tons and 14,000 tons. The total tonnage pasing the Soo canal in 1913 was nearly 80,000,000 tons. Fig 3 shows the estimated annual valuation of freight passing the Soo from 1887 to 1912, showing an increase of slightly more than 1000 per cent during 25 years. The coal passing through the Soo canals in 1855 was 10 per cent of the total tonnage for that year; in 1912 the percentage was 20.6 per cent.

The gradual reduction of freight rates for water transportation of coal to Lake Superior for 25 years is also shown in Fig. 3, from which it will be noted that the rate in 1912 was 30 cents per short ton, or only one third of that in 1887.

Forty years ago, it was necessary to guarantee return cargo for a boat, before chartering it for a trip to the head of the lakes. At the present time, however, the eastbound shipments from Lake Superior are about three and one-fourth times as large as the westbound shipments, with the result that many boats engaged in the iron ore trade return light on the westbound trip.

The increasing tonnage of coal handled from mines to lake and seabord ports has, in conjunction with the iron ore traffic from the lower lake ports to furnaces, led to the introduction of railroad cars of large capacity, with corresponding development of track and motive power, until today there are several hundred 90-ton cars in service on at least one road, transporting coal to seaboard, which is from six to twelve times the size of coal cars of 40 years ago, and provision is now being made at the docks for handling still larger cars.

TRANSFER OF COAL FOR LAKE SHIPMENT

The transfer of coal at the lower lake ports is ordinarily made direct from cars to boats without stocking. Prior to 1892, coal was loaded to boats from railroad cars either by wheelbarrow or by simple derricks equipped with small tubs, into which coal was dumped or shoveled, depending upon the kind of cars. In about 1892, however, the first successful car dumper (Fig. 4) was built at Ashtabula on Lake Erie for dumping the entire contents of gondola cars into vessels at a single operation. This was an end dumper designed by Mr. G. H. Hulett and built by the McMyler Manufacturing Company, which tilted the car endwise, requiring special gondola cars with end doors for discharging the contents of the car into the boat. After the installation of a second similar end dumper at Fairport in 1893, there followed in rapid succession several types of side car dumpers, known respectively as the McMyler, Long, Brown, Thornburg and Hulett car dumpers or tipples, which, as the name indicates, tilted the cars sidewise and permitted the handling of all types of gondola cars, discharging the coal over the sides of the cars into a concentrating apron or hopper, Figs. 5, 6, 7, 8 and 9. So far as specified above, the process of handling the coal was much the same by the various side car dumpers, but for the remainder of the process, in which the coal is transferred from the concentrating apron or hopper to the hold of the vessel, there are three methods.

a That in use on the earlier dumpers in which the coal was discharged from the hopper direct to the hold of the boat through simple short chutes;

b That in use on several of the dumpers, built between 1895 and 1900, in which the coal was discharged from the concentrating hopper into two or more bottom dump skips of sufficient aggregate capacity to hold the contents of a car, these skips being then carried over the boat on rams or on overhead track and lowered into the hatch before dumping, with view to keep-down the breakage;

c That in use on all, or nearly all, the dumpers built within the past 15 years, and on a few earlier ones, in which the flow of the coal is measurably controlled within articulated, entirely enclosed, telescopic chutes or spouts, which are extended to the bottom of the boat for starting the pile of coal in the hold, and gradually raised as the pile is built up, thus largely avoiding free fall of the coal in order to reduce breakage.

The number of car dumpers in service is increasing rapidly, and at present there is in progress the installation of several large car dumpers designed for handling forty 100-ton cars per hour. In all the car dumpers, except a few of the very earliest ones, every precaution has been taken to avoid breakage of coal.

DOCKS FOR RECEIVING, STOCKING AND RESHIPPING COAL

At the receiving ports, in addition to the unloading of coal from vessels and loading to cars for reshipment by rail, provision is made for the stocking, during the season of navigation of about seven months, of several million tons of coal to serve as reserve stock for supplying the heavy winter demands, and also to be drawn upon for the filling of such orders, during the season of navigation, as cannot be reshipped direct

from boats without docking. The docks for receiving, stocking and reshipping of coal are built out from the shore and vary in width from about 400 ft. to about a quarter of a mile, and in length from about 1000 ft. to three-quarters of a mile. Ordinarily these docks are served by a single slip along one side, although a few of the wider docks, which are equipped for unloading on both sides, have two vessel slips for discharging cargo. The depth of water in these slips should be as much as 21 ft, and some slips have been dredged to a depth of 26 ft. or more below U. S. mean low water datum. The slips are of various widths from about 60 ft. or 75 ft. up to about 200 ft.; in the wider slips provision having been made for the passing of two of the widest vessels under tow. The storage areas are surrounded on the water sides by timber cribs, extending from somewhat below the bottom of the slip to dock level at an elevation of approximately 6 ft. above mean low water; or by combination cribs, in which the lower timber part is capped with concrete, which extends from dock level to somewhat below the surface of the water. In both types of construction, the timber cribs are ordinarily sand filled and additional stability is provided by the driving of piles in front of the front and back walls, and further in some instances by anchoring the cribs to piles driven well back in the dock area. The dock area is usually filled with sand deposited by hydraulic dredge, which gives very satisfactory results, as this method of filling insures against settlement, providing the original bottom is of suitable nature. This district is favored in having an abundant supply of river and lake sand suitable for filling purposes. The coal storage area is covered either with a hard or soft wood plank floor, 2 in. or 3 in. thick, or is paved with concrete.

The machine tracks on which the coal hoists and coal bridges and other movable equipment travel along the dock, are ordinarily of pile and heavy timber, or pile and concrete construction. For tracks on which the heavier bridges travel, 100 lb., high-grade, steel rails laid in either one or two lines are required at each track, and when the pile and concrete construction is used, the rails should be carried directly either on continuous longitudinal timber stringers, or on wood cross ties for cushioning the rails.

The proper provision for the storage of loaded cars and empties, and the loading and weighing of cars, with sufficient additional trackage to supply dispatch in switching service, requires from two or three to five miles of railroad track per dock, and the proper serving of these tracks requires extensive belt-line facilities.

DEVELOPMENT OF EQUIPMENT FOR UNLOADING, STOCKING AND RELOADING FOR RAIL SHIPMENT

Prior to 1876, the equipment for unloading coal from vessels comprised a tub formed of a half oil barrel, which a horse, traveling along the dock, hoisted by means of ropes passing around deflecting sheaves located on the dock near the water front, and thence over snatch blocks suspended on fore and aft ropes spanning the distance between masts on the vessel, permitting the shifting of the tubs along the suspension rope from hatch to hatch. In unloading by this method, the boats, which were of 300 tons to 700 tons capacity, were required to lay up about a week. After hoisting, the coal was dumped into wheelbarrows and transferred to stock pile on the dock, for which purpose wheeling planks were provided, extending from a point over the boat to the rear side of the dock, which at this time had a width of about 50 ft to 75 ft. These wheeling planks were carried on wooden supports or horses, of sufficient height to clear the vessel rail, which, at the beginning of unloading, would be about 3 ft. to 5 ft above the dock. From time to time, as the boat rose in being unloaded, it was necessary to interrupt the taking out of coal, while the wheeling gang blocked up the several bents supporting the wheeling plank on the dock to suit the new height of boat. Delays incident to this work occupied about 50 per cent of the total unloading time. This first process is shown on Fig. 10.

In 1876, the first improvement was made at Duluth, which largely avoided this delay, permitting practically continuous work in the actual discharging of the cargo. As a consequnce of this first improvement, which resulted in greatly increasing dispatch in unloading, the lake freight rate was cut about 75 cents per ton, amounting to about 250 per cent of the present lake rate. While this change was of a very simple nature, it represents a greater saving per ton than any subsequent improvement, and in fact is one of the few developments which has resulted in marked increase in dispatch with actual reduction in cost of equipment and operation.

This revised method of unloading is shown on Figs. 11 and 12, from which it will be noted that similar but simplified equipment was used, and that the improvement resulted principally from the method of supporting the wheeling plank and of stocking the coal. The wheeling plank was placed at a fixed height of about 10 ft. above the dock, and was carried on adjustable horses placed on the deck of the boat and on a horse located on the front of the dock. As the boat rose, the wheeling plank was maintained at a constant height above the dock level by shifting the cross beams, which carried the wheeling plank on the horses, located on the vessel deck, to successively lower supports on these horses, which operation was readily performed, and without appreciable delay to unloading operations.

Another feature, which reduced the time and simplified the operation, was the method of building the stock pile, which, in the improved method, required

the wheeling plank to extend only to the crest of the 10-ft. pile at the front of the dock, from which point the pile was extended at full height to the rear of the dock, and served as support for the wheeling plank, thus reducing the number of horses required. In the original method, the wheeling plank extended the full width of the dock from the start, and the coal pile was built up as the boat rose. The writer is advised by the dock superintendent, who first used this improved method at the head of the lakes, that both the original method referred to and this improved method were in general use over the lakes at the times mentioned.

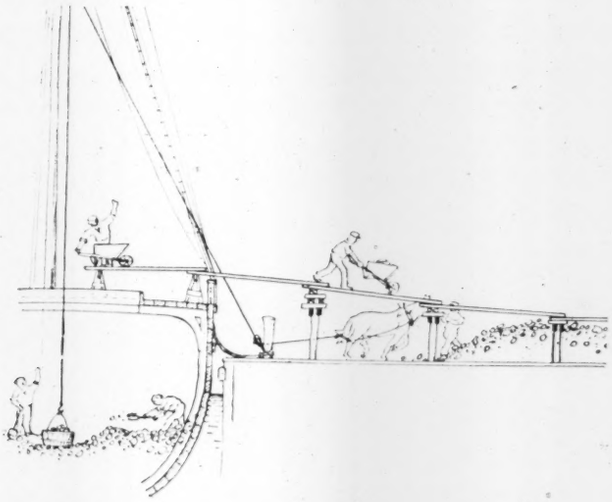


Fig. 10 Primitive Method of Unloading Coal, in General use over the Lakes prior to 1876

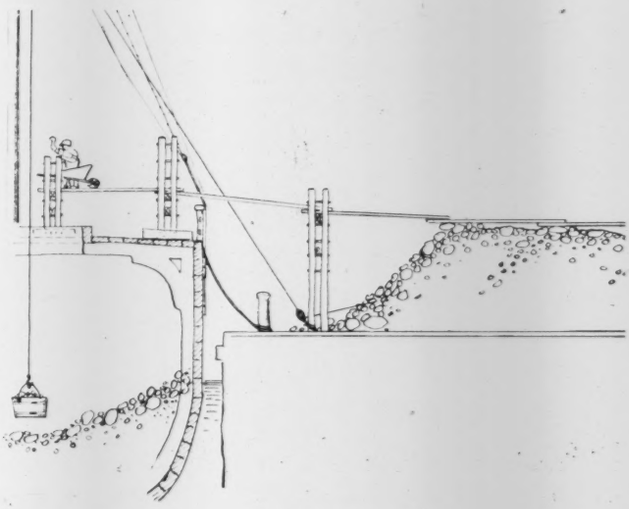


Fig. 11 First Improved Method used in 1876, in General use over the Lakes

Fig. 12 Early Method of Unloading Coal and Iron Ore by Hand Shovelling and Wheelbarrow

A simple form of derrick was in use in Chicago in 1877 for the purpose of hoisting coal from boats. About 1878 or 1879, a special type of derrick was in

troduced on the North Western Fuel Company's Duluth Dock No. 1, six of which were spaced along the dock front about 66 ft. apart, and arranged for operation in pairs, it being possible to operate only one pair on a boat at a time. The tubs on the two derricks were hoisted simultaneously by means of a small hoisting engine. These derricks were similar to those still in use on some of the older docks at Duluth and Superior, and were equipped with half-ton Stuebner self-righting tubs of the same general type as the tubs now in use. Tracks were provided along a longitudinal unloading platform about 20 ft. above dock

Fig. 13 Dodge Covered Anthracite Storage Plant, Lehigh Valley Coal Sales Company, Superior

level with turnouts to tracks on transverse timber run ways, on which dump cars were operated by hand, making it possible to stock the coal to a depth of about 20 ft. on any part of the dock, irrespective of the position of the boat. This gave as great flexibility in the distribution of coal in stocking as is afforded by that type of present day plant in which bulk is broken at dock front and in which separate hoisting, longitudinal transferring and stocking units are employed. This principle of flexibility was recognized in this first steam-operated plant, although it remained for later installations to perfect the structural and mechanical details.

About 1881 or 1882, a third and marked improvement was made by the introduction of a main lineshaft running the full length of the dock and equipped with an individual hoist for each derrick, which permitted the independent operation of each derrick.

In 1883, a Cleveland concern installed for the Ohio Central Barge & Coal Company on its dock in Duluth, now Pittsburgh Dock No. 1, eight wooden bridges of 150 ft span, arranged four along each side of the dock and patterned after similar bridges in Cleveland. These bridges were built in pairs, with boiler and two hoisting engines located on the double pier, from which point a rope trolley, equipped with 1-ton tub, was operated on each span. They were equipped with hinged aprons extending over the boat when in service, and raised for clearing vessels when not in use. Coal was stocked 28 ft. high. The bridges were moved along the dock by hand power. These were the first coal-handling bridges at the Head of the Lakes.

Further improvement was introduced in about 1885 or 1886 in the spacing of the derricks to suit the hatch spacing on the boats, which was now becoming more uniform, making possible the working of every second hatch simultaneously without shifting the boat. About this time, also, cables were installed on the level stocking runways for pulling dump cars in both directions by power, after having been pushed from the unloading platform to the runways by hand.

Prior to the installation of the first reloading runway in about 1885, reloading to cars for rail shipment was done by wheelbarrow. From 1885 to 1888 or 1889, these reloading runways were equipped with trolleys carrying self-righting tubs. The first shovel bucket, which was made by Mr. Dole of Cleveland, was put into service at the Head of the Lakes on the Pennsylvania and Ohio dock, at present known as the Boston Dock of the St. Paul & Western Coal Company.

In 1887, nine portable, steam, timber, Hunt hoists, each equipped with ¾-ton tub and a cable railway stocking system, were put into operation on the Lehigh Coal & Coke Company's dock in Superior on St. Louis Bay, which is the North Western Fuel Company's present Dock No. 2. The hoists were located on an elevated platform at the dock front, along which they traveled from hatch to hatch in unloading vessels. These hoists were placed opposite the runways on which it was desired to stock the coal. Side dump cars carried the coal back to the stock pile by gravity, at the same time raising counterweights which returned the empty cars to the hoists for reloading. As these cars had no longitudinal movement along the dock, it was necessary to stock the coal opposite the point where it was unloaded, making in this respect a less flexible system than that last mentioned, in which derricks served by stocking cars traveling longitudinally on the unloading platform and transversely on runways were used.

In 1888, the Brown Hoisting Machinery Company installed for the Pioneer Fuel Company four steel bridge tramways on their dock on Rice's Point Duluth, now operated by the Clarkson Coal & Dock Company. These bridges, which are still in use, have a span of 188 ft., a rear 80 ft. cantilever extension, and a hinged apron 34 ft. in length for lowering over the boat. Each bridge is carried on a tilting shear leg located at the front near the apron hinge. The two outer bridges are carried on single piers, and the two inner bridges on a double pier at the rear, spanning two railroad tracks. A boiler and four steam hoisting engines are installed on the double pier for operating the four bridges, each of which is equipped with a rope trolley carrying a 1-ton tub. The bridges are

propelled on machine tracks along the dock in part by steam and in part by hand power. The bridges are inclined with a rising grade toward the back of the dock, and are pivoted at the piers to permit skewing horizontally to suit hatch spacing.

In 1890, three similar Brown bridge tramways were erected on the Silver Creek Coal & Dock Company's dock, Superior, which was later taken over by the Philadelphia & Reading Coal & Iron Company, and now operated by the Great Lakes Coal & Dock Company. In 1893, three Brown bridges of the same type were erected on the Pennsylvania & Ohio Fuel Company's dock at Duluth, which later came into the hands of the Boston Coal & Wharf Company. In 1899 a single additional bridge was installed on this dock, this last bridge being one of the latest installations, if not the last one, where tubs were used exclusively, or before the introduction of clamshells.

In 1893, the McMyler Manufacturing Company installed several steel bridges, of 180 ft. span with 100 ft. cantilever, on the dock of the Youghiogheny & Lehigh Coal Company, Superior, on which tubs were at first used but later replaced by $1\frac{3}{4}$-ton clams. This dock is now known as the Pittsburgh Dock No. 3, and is operated by the Reiss Coal Company. The Mead Company, in about 1895, installed on this dock an automatic car and cable railway system.

In 1896, the McMyler Manufacturing Company installed several stationary timber steam hoists, fitted with steel booms and equipped with rope trolley carrying clamshell grab bucket, on the dock of the Lehigh Valley Coal Sales Company at Superior.

In about 1899, four steel suspension cable tramways, operated by Lidgerwood hoisting engines, were installed on the Lehigh Coal & Coke Company's dock, Superior, which had already been partially equipped with the movable Hunt hoists previously mentioned.

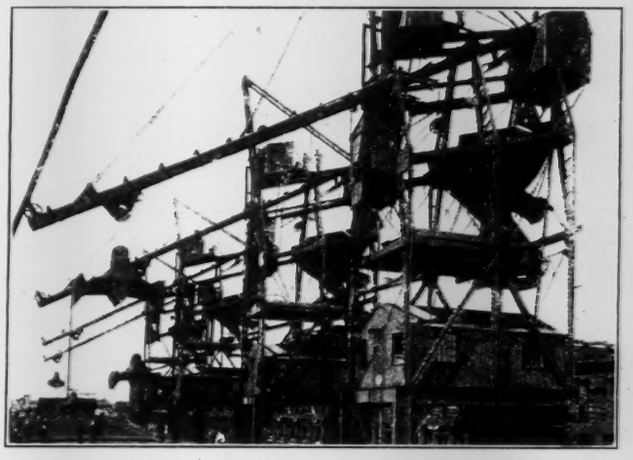


Fig. 14 Brown Hoist Towers on North Western Fuel Company's Dock No. 1, Superior, in 1902. First Electric Dock

At the time these hoists were built, or possibly a little later, they were equipped with Dole single rope clamshell buckets of about 1-ton capacity, which required hand tripping. In 1902, a fifth tramway, equipped with grab bucket, was installed by the Mead Company. Steam was furnished by main steam line from a central boiler plant at the inner end of the dock. In unloading coal was discharged into the hopper on the front pier, and stocked by means of bottom dump skips. Reclaiming was done by shovel buckets.

From 1886 to 1890 inclusive, the Dodge system of anthracite storage[1] was developed in the installation of several plants in the East, and in 1894 a 110,000-ton covered anthracite plant of this type was installed for the Lehigh Valley Coal Sales Company at Superior, comprising two units of 55,000 tons each shown in Fig. 13.

[1] Described in a paper on Hoisting and Conveying Machinery by Geo. E. Titcomb, Trans. Vol. 30, p. 123.

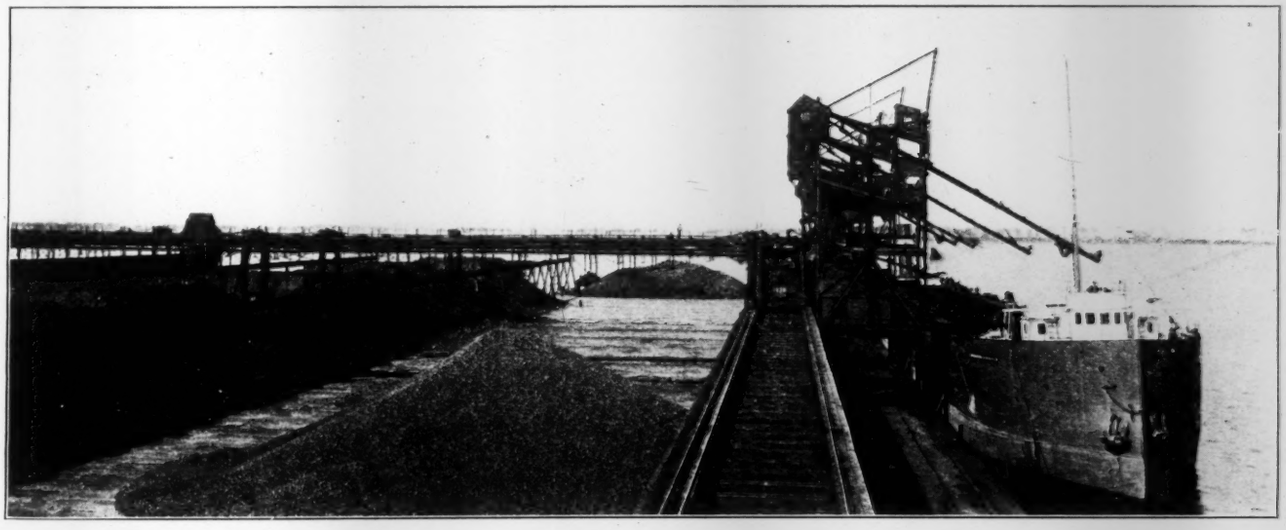


Fig. 15 Brown Hoist Towers, Bridges and Transfer Cars on North Western Fuel Company's Dock No. 1. First Electric Dock

FIRST ELECTRIC COAL HANDLING PLANT

In 1901, the Brown Hoisting Machinery Company started for the North Western Fuel Company, the construction of the first electric coal handling plant ever installed. This plant consists of four hoisting towers with one and one half ton clam shell grab buckets, later replaced by two ton grab buckets; three transfer cars; three stocking and reclaiming bridges, each having 155 ft. 2 in. spans and 42 ft. 9 in, rear cantilever, giving overall length of 508 ft. 3 in., and each equipped with one stocking man trolley, carrying a 7-ton self-righting tub, and one man trolley for reclaiming, carrying a 4-ton shovel bucket. The hoisting motors on the towers are controlled by drum type controllers and magnetic switches. Two continuous lines of timber bins are provided, one near the front end of the dock immedately in the rear of the hoisting towers, on which the transfer cars travel, and one at the rear of the dock forming support for the rear bridge tracks.

Coal is unloaded from the boat by means of the clamshell, and deposited in a 15-ton hopper in the tower. The stocking trolley with its 7-ton tub is brought by the transfer car to place opposite the tower bin, from which it receives the coal. The transfer car then runs to a bridge, with which it registers, permitting the stocking trolley to deliver coal to stock pile. The function of the transfer car is to give flexibility of operation in unloading, stocking, reclaiming and direct reshipment by rail, thus permitting the stocking of coal wherever desired on the dock, irrespective of the location of the vessel and hoisting towers, and equal flexibility in loading out.

Later a fourth bridge was added with reclaiming trolley. Direct current is furnished this equipment from a central generating system located on the dock. To relieve the generators of the high peaks, incident principally to accelerating in hoisting and traveling, a storage battery was installed, having momentary output of 2040 amperes, later increased to 2720 amperes. The rated capacity of this plant was the unloading of a 5000 ton boat in ten hours. In actual performance, however, this has at times been considerably exceeded. The construction and equipment of this dock is important, as it was the first electrically operated dock in the world; the first on which coal handling man trolleys were used; and the first coal dock on which all the operations were performed by power, making possible a new record for speed and capacity (Figs. 14, 15, 29 and 30).

In 1902, three Brown bridge tramways were installed for the Eastern Railway Company of Minnesota, and later taken over by the Jones & Adams Company. This dock is now known as Pittsburgh Dock No. 6, and operated by the Island Creek Coal Sales Company. These bridges were equipped with rope trolleys carrying 1¼-ton clamshell grab buckets, and were operated by steam.

RECENT INSTALLATIONS

In 1905, the Mead Company installed, for the M. A Hanna Coal Company on their Superior Dock, a plant comprising three steam traveling unloading hoists, which are mounted on a longitudinal unloading platform, each equipped with a 2-ton clamshell; two 262 ft. span traversing bridges for stocking and reclaiming bituminous coal, and Mead automatic cars and cable railway for stocking both bituminous and anthracite coal. In stocking bituminous coal, the automatic cars run along tracks carried on transverse stationary elevated runways, leading to the longitudinal tracks on the bridges, giving flexibility in stocking operations. In stocking anthracite, the course of the car is confined to the elevated stationary runways

A similar installation was made by the Mead Company about the same time on the Northern Coal & Dock Company's dock, Superior.

The Zenith Furnace Company's dock, Duluth, is equipped with four Mead unloading towers handling 2-ton clams, one Mead bridge and Mead automatic car and cable railway system.

In 1906 and 1907 the Duluth and Iron Range Railroad Company's coal dock at Two Harbors was equipped with a Mead plant comprising three steam hoisting towers handling two-ton clams, and mounted for traveling on a 40-ft. high steel trestle; an electric four-ton automatic car and cable railway system; and an electrically operated stocking and reclaiming bridge handling a two-ton shovel bucket.

This dock has a storage area about 275 ft. wide by 900 ft. long, and a nominal storage capacity of about 150,000 tons. Owing to local conditions the dock does not directly face the slip, which requires the hoisting towers to operate at some distance from the storage area, giving conditions to which the portable hoist and cable railway system is peculiarly adapted.

A recent Mead installation of same general type but different in detail, made on the Washington Street dock of the Milwaukee Western Fuel Company at Milwaukee, and equipped with screening plant in bridge in place of the fixed loading bins, is shown in Fig. 16.

The stocking of coal by means of a belt conveyor on a bridge is a method used by the Robins Conveying Belt Company. In one plant of this type coal is stocked on the dock at the rate of 600 tons per hour, the conveyor having a traveling tripper for distributing the coal, which it receives from a second belt conveyor, which in turn receives the coal from a system of conveyors at the unloading towers. Reclaiming is done by a clamshell bucket at the rate of 300 tons per hour.

In 1906, a 200,000-ton covered anthracite storage plant for stocking coal 60 ft. high was installed on section 2 of the North Western Fuel Company's Superior Dock No. 1. Coal is unloaded by two Heyl & Patter-

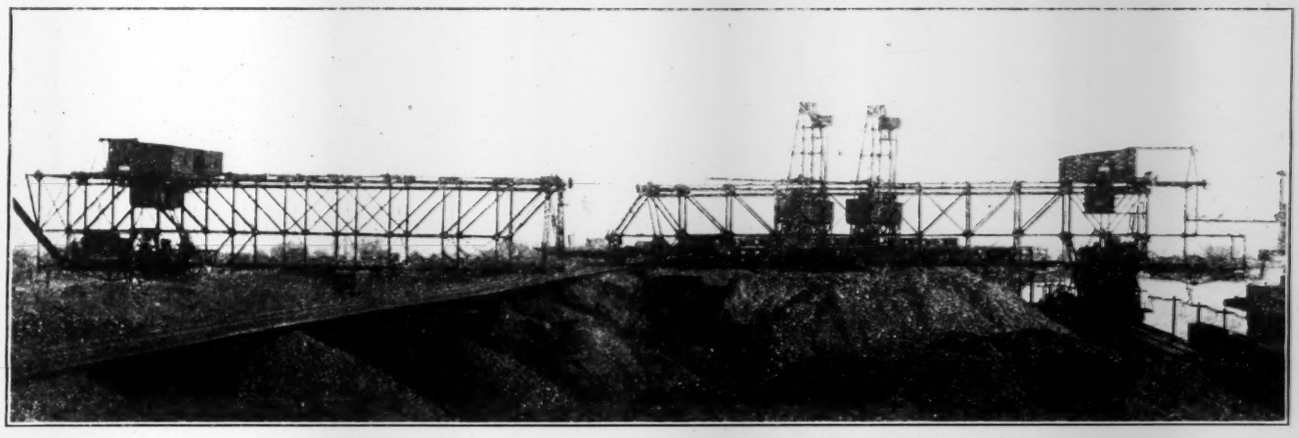


Fig. 16 Mead Hoist Towers, Automatic Cars, Cable Railway and Bridges, Milwaukee Western Fuel Company's Washington Street Dock, Milwaukee

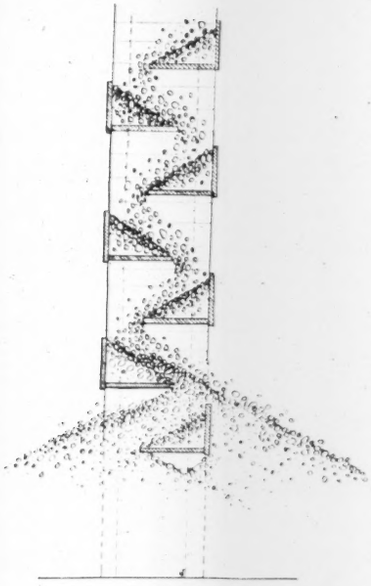


Fig. 17 Humphrey Shelf Lowering Chute

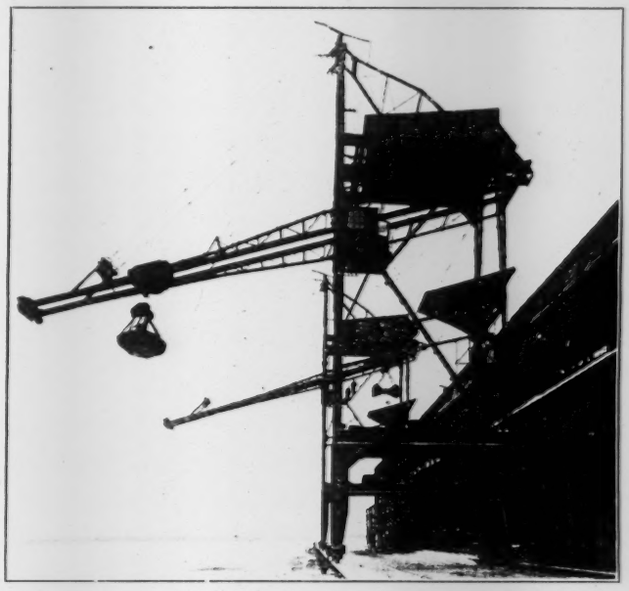


Fig. 18 Heyl and Patterson Anthracite Hoists and Dodge Stocking Conveyor, installed on North Western Fuel Company's Superior Dock No. 1, 1906

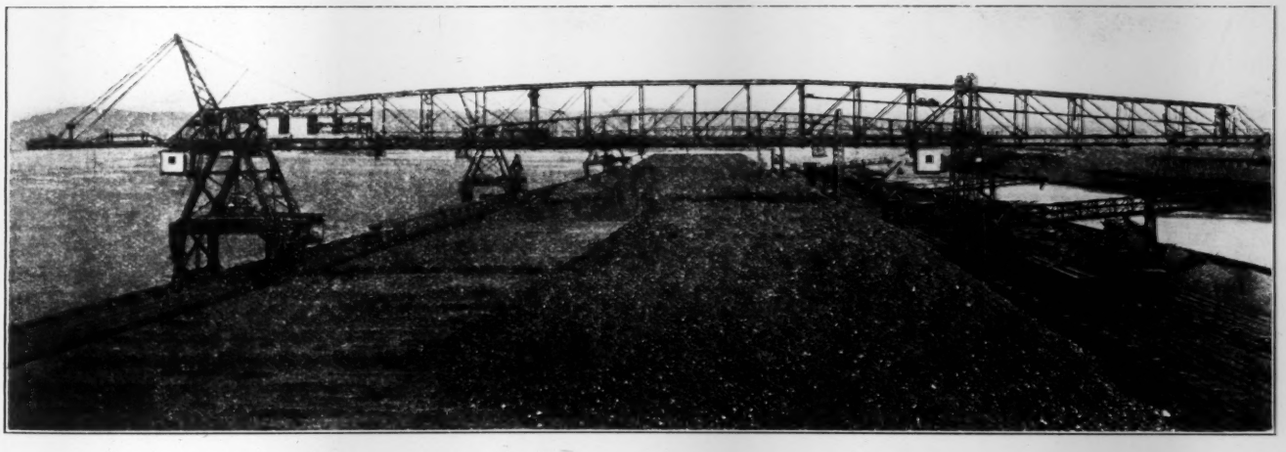
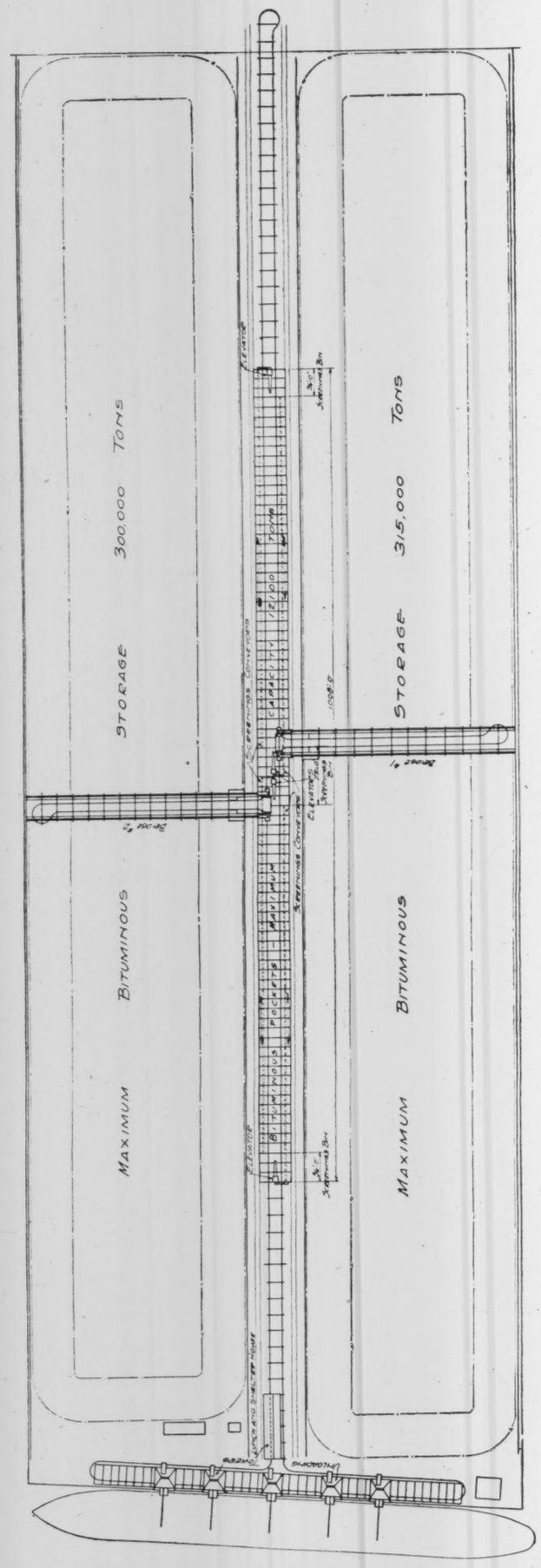


Fig. 19 Dodge Coal Handling Bridges and Auxiliary Equipment, Berwind Fuel Co., Superior



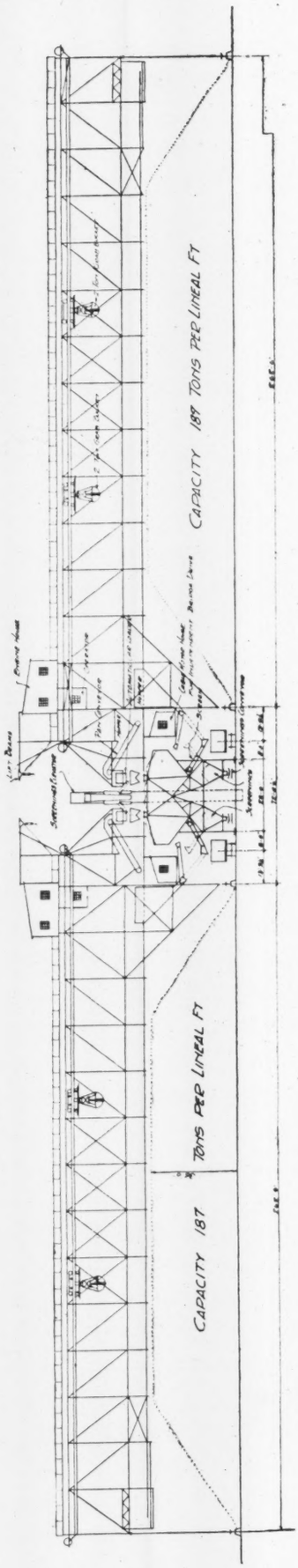


FIG. 20 MEAD HOISTS, AUTOMATIC CARS, CABLE RAILWAY SYSTEM AND STOCKING AND RECLAIMING BRIDGES, DULUTH, MISSABE AND NORTHERN RAILWAY COMPANY'S DOCK, DULUTH

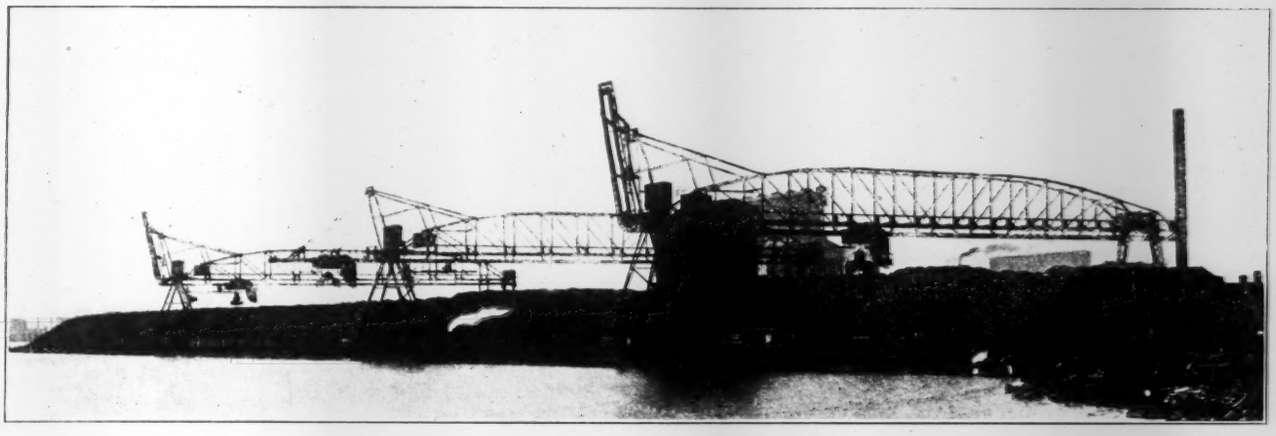


Fig. 21 Three Heyl and Patterson Bridges on North Western Fuel Company's Dock No. 2, Superior

son electric hoists, equipped with 3-ton clamshells, and stocked and reclaimed by means of Dodge reversing, electric-driven, ribbon bottom, flight conveyors of 250 and 300 tons hourly capacity. In stocking, coal is discharged from the top run of conveyors into storage building or 3000 ton shipping pocket, and reclaimed by the bottom run of these conveyors, working in tunnels beneath the coal pile. Breakage of coal is avoided, when starting the pile in stocking, by lowering the coal through Humphrey shelf lowering chutes, Fig. 17. After building the pile to full height at a single point, the ribbon bottom of the conveyor is drawn in, or extended, as the crest of the pile advances. The coal is loaded for reshipment at the single 3000-ton shipping pocket. This plant is shown on Fig. 18.

In 1907 or 1908, the Wellman-Seaver-Morgan Company installed two Hulett bridges of 176-ft. span with 130--ft. cantilever, and equipped with 2-ton grab buckets, on the Boston dock of the St. Paul & Western Coal Company. These bridges are steam operated and are provided with separate hoists and trolley engines, and controlled by two operators.

One of the larger electric bituminous coal handling bridge installations, on which the rope trolley is used, was made on the Berwind Fuel Company's Dock in Superior in 1907. Fig. 19. This is one of the later trolley installations prior to the general introduction of the large man trolley bridge. These bridges are 506 ft. long with 295 ft. span, equipped with 3-ton clamshells, and are supplemented by revolving locomotive cranes and movable screenings tower. All motions of bridge and bucket are controlled by one operator from either of two fixed control stations. All equipment on this dock is electrically operated by means of 400-volt, three-phase, alternating current.

Fig. 20 shows the Duluth, Missabe & Northern coal dock at Duluth, which is 604 ft. wide by 2000 ft. long On one half of this dock was installed in 1907 a Mead plant, comprising three portable hoists equipped with 2-ton clams, 4-ton automatic car and cable railway system, and a stocking and reclaiming bridge with 2-ton shovel bucket. Provision has now been made for similarly equipping the other half of the dock, using 4-ton clams, in place of the 2-ton clams, on two additional hoists.

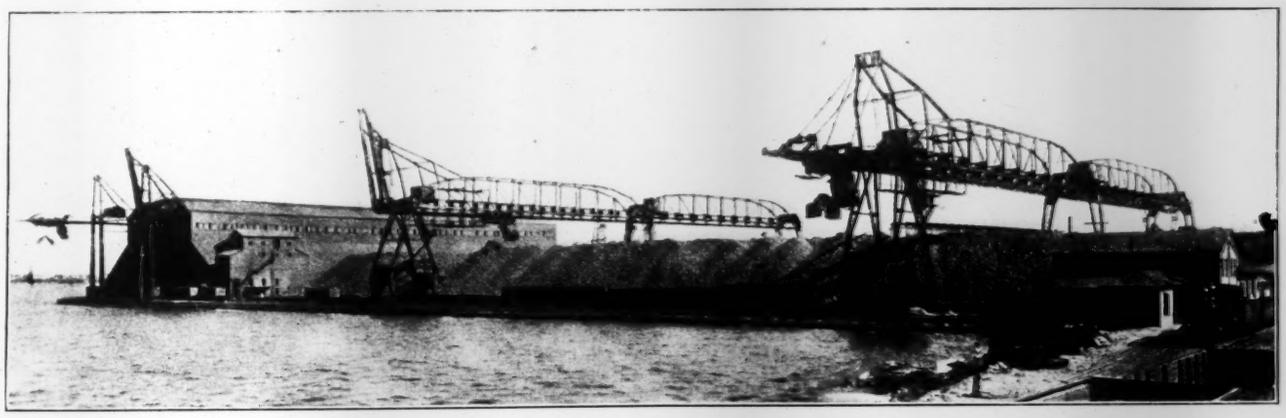


Fig. 22 Heyl and Patterson Bituminous and Anthracite Plant, Philadelphia and Reading Coal and Iron Company's Dock, Superior

ELECTRICALLY-OPERATED MAN-TROLLEY COAL BRIDGE

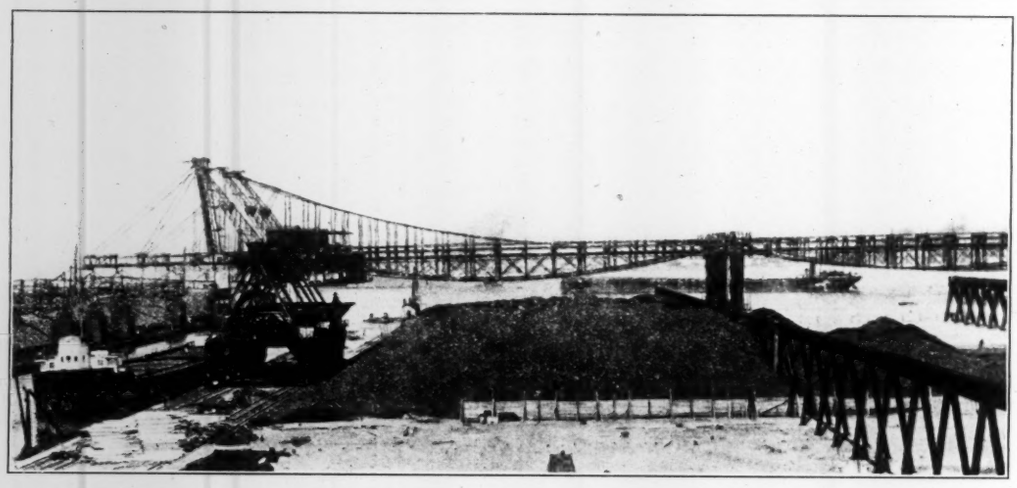


FIG. 23 BROWN HOIST BRIDGES ON PITTSBURGH

The first electrically operated man trolley coal bridge, in which the unloading, stocking, reprepar-ing, reclaiming and loading out were accomplished by a single unit, was installed by Heyl & Patterson on the North Western Fuel Company's Superior Dock No. 2 in 1909. This bridge has a span of 363 ft. 4 in. and is 455 ft. 6 in. long overall, with screening and loading out plant mounted on the shear, and run of pile loading plant on the pier. The man trolley was equipped with 5-ton Heyl and Patterson clam for unloading and reclaiming bituminous coal, this being the largest clam thus far installed at the head of the lakes. One man controls the operation of the trolley in unloading, stocking and reclaiming and bridge traversing. This bridge is operated by three-phase, 25-cycle, 440-volt, alternating current, stepped down from 13,200 volts by main transformer located on the bridge. This is the first traveling bridge to take current from high-tension trolley feeder line along the dock by means of collector shoes. The man trolley is equipped with two hoist motors and two rack motors, operated by master controllers and magnetic switches. The friction clutches and brakes are operated by compressed air. Dynamic braking is provided for racking and lowering, for which direct current is supplied by a small motor generator set delivering direct current at 40 volts.

Beginning with 1909, there was an unusual development of docks and equipment, and within the next few years, ten bridges, similar to the ones just described, were installed in Superior and Duluth, as follows: two on the Carnegie Fuel Company's Dock No. 1, Superior; two on the Philadelphia & Reading Coal & Iron Company's Dock No. 2 in Superior; two on the Island Creek Coal & Sales Company's dock in West Duluth; two on the North Western Fuel Company's Dock No. 2, Superior; one on the North Western Fuel Company's Dock No. 1, Superior; and one on the Reiss Coal Company's dock—Pittsburgh Dock No. 3—in Superior. With the last bridge installed on the North

FIG. 24 PANORAMIC VIEW OF MEAD ANTHRACITE AND BITUMINOUS

Coal Company's Dock No. 7, Duluth

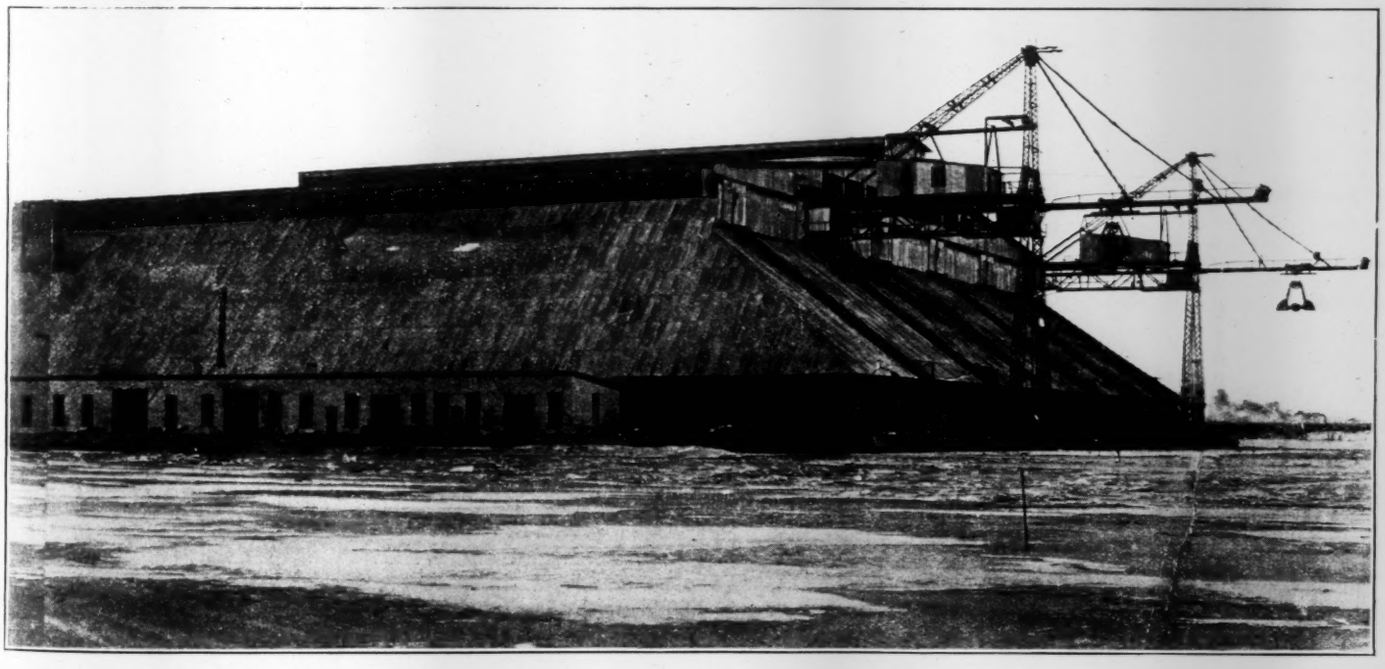
Western Fuel Company's Dock No. 2 in 1912, the screening plant, which was somewhat more elaborate, was mounted on separate trucks and attached to the bridge for traveling. Fig. 21. A 6-ton clamshell was provided for this bridge, and the 5-ton clams on the other two bridges on this dock were also replaced by the 6-ton clams. In order largely to eliminate hand shoveling in cleaning up boats, after the unloading clam had picked up the coal within reach, a specially designed, 4-ton clean-up clam was developed. This clean-up clam is described in more detail in a later paragraph.

In 1910, in conjunction with two of the bituminous bridges above mentioned, there was installed on the Philadelphia & Reading Dock at Superior, an electric, covered anthracite plant, comprising two stationary unloading hoists equipped with rope trolleys carrying 5-ton clamshells, a double storage building of steel construction 350 ft. by 500 ft., a mechanical screening plant for repreparation of the coal, and a shipping pocket for reloading at a single point (See Fig. 22).

In 1910, an extension 144 ft. by 480 ft. was made to the North Western Fuel Company's Superior Dock No. 1 anthracite storage plant, in the form of a steel storage building equipped with a 3-ton man trolley, which carries a 5½-ton skip for stocking and a 3-ton clamshell for reclaiming, with necessary additional elevators and conveyors, to supplement the original conveyor system, for transferring coal to and from the building. This gives a total anthracite storage capacity of about 265,000 tons on this dock.

Fig. 24 shows an electrical installation on the Carnegie No. 2 Dock, Duluth, comprising two Mead bituminous bridges of 382 ft. span, and anthracite plant consisting of two traversing unloading hoists equipped with clams, and a steel storage shed 280 ft. by 404 ft. equipped with rope trolleys, operating on six runways.

An unusual arrangement of bridges was installed in 1911 on the Pittsburgh Coal Company's Dock No. 7 by the Brown Hoisting Machinery Company (Fig. 23). This installation comprises three two-span bridges on



Plants, installed on Carnegie Dock No. 2, Duluth, in 1912

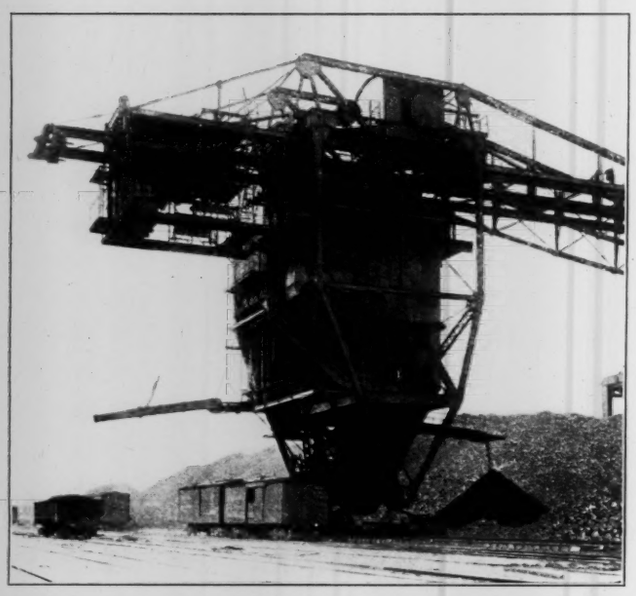


FIG. 25 BROWN SCREENING PLANT ON PITTSBURGH COAL COMPANY'S DOCK NO. 7, DULUTH

the front of the dock and two single-span bridges at the rear, the spans having a uniform length of 242 ft. Each of the two-span bridges and one of the single-span bridges is equipped with a man trolley carrying a 5½-ton grab bucket. The single-span bridges may be operated separately, or may be registered with any of the two-span bridges, thus forming continuous runways 726 ft. long across the dock; or including cantilevers and apron the overall length is 839 ft. Other interesting features of this installation are the swiveling trolley and the screening plant. The swiveling man trolley, provided with turntable to facilitate cleaning up the hold of boats, is further described in a later paragraph. A very complete screening plant, of new design and large capacity, is located in the rear pier of one of the single-span bridges, Fig. 25. This is furnished with bins, shaking and revolving screens, and the necessary elevators and conveyors for the preparation of lump coal and the separation of the degradation into nut, stove and screenings, with provision for loading box and gondola cars or returning to stock pile on the dock, as desired. Last year, a similar installation with longer span bridges was made on the Pittsburgh Coal Company's Dock No. 5 in Superior.

The coal handling plant installed last year on the Canadian Pacific Railway Company's Fort William Dock by the Wellman-Seaver-Morgan Company, consists of two automatic unloaders equipped with 8-ton scoops, a man trolley bridge carrying a 9-ton grab bucket, and a transfer car system with trestle and bins to give flexibility to the plant. Transfer cars are of 35-ton capacity, and are equipped with recording scales accurately weighing all the coal they handle. The plant has a capacity for unloading a 10,000-ton boat in 15 hours. Thirty loading pockets are provided from which cars are loaded by means of a double-ended Christy box-car loader, giving a very large loading out capacity. Fig. 26 shows a good general view of this plant.

COMPARISON OF ELECTRICALLY OPERATED PLANTS: 1902-1913

The tendency towards a few large units in the development of coal handling equipment within the past few years is shown in the comparison of the electrically operated plant installed on section 1 of the North Western Fuel Company's Dock No. 1 in 1901, and the electric coal handling bridge installed in 1913 on section 3 of the same dock, these being the first and latest electrically operated plants installed at the Head of the Lakes. The plant first mentioned has, as previously described, four hoisting towers and four bridges with the necessary transfer cars, having rated capacity for unloading a 5000 ton boat in 10 hours, and serving a dock about 560 ft. by 1100 ft. on which bituminous coal is stocked 30 ft. high. The second installation referred to, on section 3 of this dock, consists of one Heyl & Patterson bridge having a single span of 551 ft. and being 712½ ft. long overall, on which is operated a man trolley equipped with a 12-ton clamshell for unloading, stocking and reclaiming, and 6-ton clean-up clam. This bridge serves a section of the dock about 610 ft. by 750 ft. and stocks bituminous coal to a height of 50 ft. Coal is reloaded to cars at both ends of the bridge and rescreened, when desired, at the pier end. Provision has also been made in the construction of the bridge for the future installation of a more elaborate detached screening plant for re-

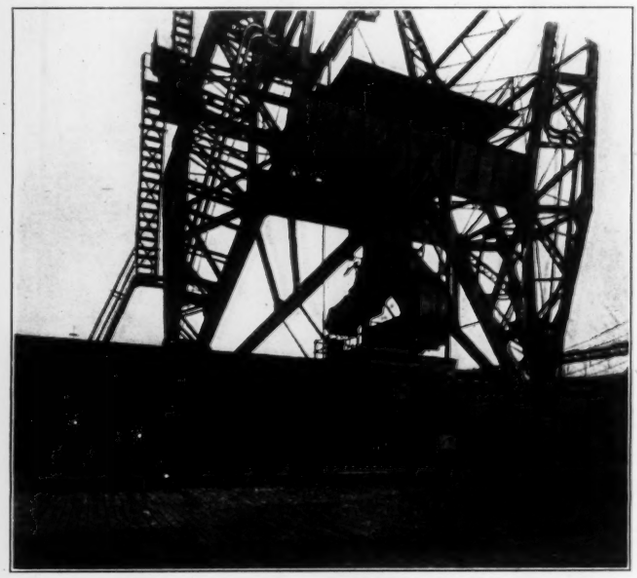


FIG. 27 LOADING PLANT AND TRUCKS AT SHEAR END OF NORTH WESTERN FUEL COMPANY'S BRIDGE NO. 5, DOCK NO. 1, SUPERIOR

Fig. 26 Hulett Automatic Unloaders, Transfer Cars, and Stocking and Reclaiming Bridge on Canadian Pacific Dock, Fort William

preparation of coal. There is required on this bridge for its operation one man trolley operator and one oiler. This bridge has a rated capacity for unloading and stocking coal on dock from a 10,000-ton boat in 20 hours, acomplishing with a single unit and with only two men on the bridge, as much as four unloading hoists with a total of eleven units accomplished with about ten or twelve men on the equipment in the first mentioned installation (Figs. 27 and 28).

An incidental advantage of bridges long enough to span the entire width of dock is the elimination of intermediate runways or supports from the stocking area, which in the short span bridges, reduce the storage space and obstruct the operations of stocking and reclaiming.

At the present time two installations are being made, one on the Reiss No. 3 Dock at Superior, which is being equipped with a Heyl & Patterson bridge; and another on the Missabe and Northern Dock at Duluth, comprising Mead hoists and cable railway system with bridge, as previously mentioned.

METHODS OF HANDLING AT RECEIVING DOCKS

While it is evident, from a consideration of the several types of plants briefly described above, that there are several methods of handling the coal at the receiving docks, it is true that these methods group themselves under two general heads, as follows:

a That in which the bulk of coal is broken at the dock front by temporarily storing the coal in a receiving hopper, located, in the hoists, for later discharging to independent units for transferring to stock pile;

b That in which coal is delivered direct to stock pile in a single operation without breaking bulk.

Under case (*a*), where bulk is broken at the dock front, the unloading is done by fixed or traversing hoists or unloaders used only for this operation, while the stocking is done by equipment ordinarily acting independently of the hoists. This stocking equipment is of various types, and the method employed for stocking is again divided into two general classes:

(1) That in which no provision is made for longitudinal transfer of the coal, necessitating its being stocked directly back of the unloading tower, so that boat must be placed opposite the area on which coal is to be stocked.

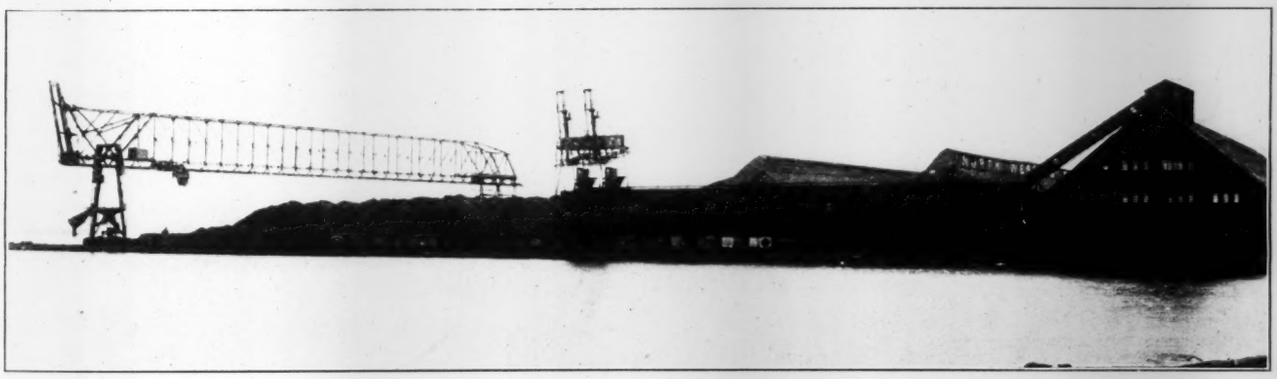


Fig. 28 North Western Fuel Company's Dock No. 1, Superior, showing Anthracite Section and Largest Coal Handling Bridge installed to Date

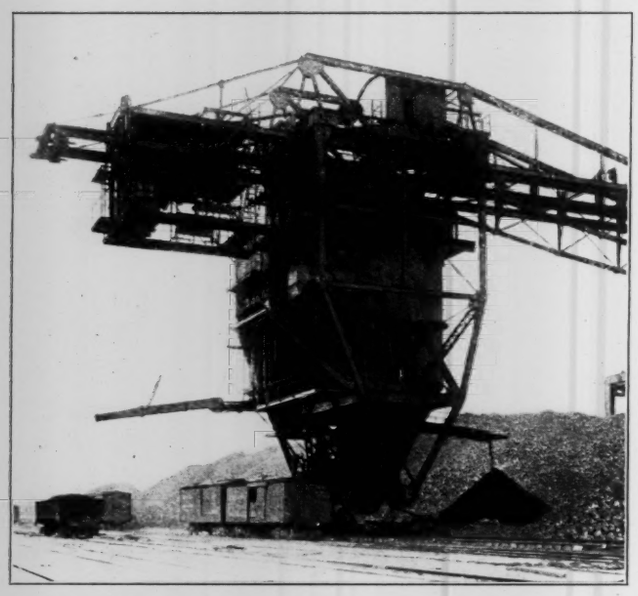


FIG. 25 BROWN SCREENING PLANT ON PITTSBURGH COAL COMPANY'S DOCK NO. 7, DULUTH

the front of the dock and two single-span bridges at the rear, the spans having a uniform length of 242 ft Each of the two-span bridges and one of the single-span bridges is equipped with a man trolley carrying a 5½-ton grab bucket. The single-span bridges may be operated separately, or may be registered with any of the two-span bridges, thus forming continuous runways 726 ft. long across the dock; or including cantilevers and apron the overall length is 839 ft. Other interesting features of this installation are the swiveling trolley and the screening plant. The swiveling man trolley, provided with turntable to facilitate cleaning up the hold of boats, is further described in a later paragraph. A very complete screening plant, of new design and large capacity, is located in the rear pier of one of the single-span bridges, Fig. 25. This is furnished with bins, shaking and revolving screens, and the necessary elevators and conveyors for the preparation of lump coal and the separation of the degradation into nut, stove and screenings, with provision for loading box and gondola cars or returning to stock pile on the dock, as desired. Last year, a similar installation with longer span bridges was made on the Pittsburgh Coal Company's Dock No. 5 in Superior.

The coal handling plant installed last year on the Canadian Pacific Railway Company's Fort William Dock by the Wellman-Seaver-Morgan Company, consists of two automatic unloaders equipped with 8-ton scoops, a man trolley bridge carrying a 9-ton grab bucket, and a transfer car system with trestle and bins to give flexibility to the plant. Transfer cars are of 35-ton capacity, and are equipped with recording scales accurately weighing all the coal they handle. The plant has a capacity for unloading a 10,000-ton boat in 15 hours. Thirty loading pockets are provided from which cars are loaded by means of a double-ended Christy box-car loader, giving a very large loading out capacity. Fig. 26 shows a good general view of this plant.

COMPARISON OF ELECTRICALLY OPERATED PLANTS: 1902-1913

The tendency towards a few large units in the development of coal handling equipment within the past few years is shown in the comparison of the electrically operated plant installed on section 1 of the North Western Fuel Company's Dock No. 1 in 1901, and the electric coal handling bridge installed in 1913 on section 3 of the same dock, these being the first and latest electrically operated plants installed at the Head of the Lakes. The plant first mentioned has, as previously described, four hoisting towers and four bridges with the necessary transfer cars, having rated capacity for unloading a 5000 ton boat in 10 hours, and serving a dock about 560 ft. by 1100 ft. on which bituminous coal is stocked 30 ft. high. The second installation referred to, on section 3 of this dock, consists of one Heyl & Patterson bridge having a single span of 551 ft. and being 712½ ft. long overall, on which is operated a man trolley equipped with a 12-ton clamshell for unloading, stocking and reclaiming, and 6-ton clean-up clam. This bridge serves a section of the dock about 610 ft. by 750 ft. and stocks bituminous coal to a height of 50 ft. Coal is reloaded to cars at both ends of the bridge and rescreened, when desired, at the pier end. Provision has also been made in the construction of the bridge for the future installation of a more elaborate detached screening plant for re-

FIG. 27 LOADING PLANT AND TRUCKS AT SHEAR END OF NORTH WESTERN FUEL COMPANY'S BRIDGE NO. 5, DOCK NO. 1, SUPERIOR

FIG. 26 HULETT AUTOMATIC UNLOADERS, TRANSFER CARS, AND STOCKING AND RECLAIMING BRIDGE ON CANADIAN PACIFIC DOCK, FORT WILLIAM

preparation of coal. There is required on this bridge for its operation one man trolley operator and one oiler. This bridge has a rated capacity for unloading and stocking coal on dock from a 10,000-ton boat in 20 hours, acomplishing with a single unit and with only two men on the bridge, as much as four unloading hoists with a total of eleven units accomplished with about ten or twelve men on the equipment in the first mentioned installation (Figs. 27 and 28).

An incidental advantage of bridges long enough to span the entire width of dock is the elimination of intermediate runways or supports from the stocking area, which in the short span bridges, reduce the storage space and obstruct the operations of stocking and reclaiming.

At the present time two installations are being made, one on the Reiss No. 3 Dock at Superior, which is being equipped with a Heyl & Patterson bridge; and another on the Missabe and Northern Dock at Duluth, comprising Mead hoists and cable railway system with bridge, as previously mentioned.

METHODS OF HANDLING AT RECEIVING DOCKS

While it is evident, from a consideration of the several types of plants briefly described above, that there are several methods of handling the coal at the receiving docks, it is true that these methods group themselves under two general heads, as follows:

a That in which the bulk of coal is broken at the dock front by temporarily storing the coal in a receiving hopper, located, in the hoists, for later discharging to independent units for transferring to stock pile;

b That in which coal is delivered direct to stock pile in a single operation without breaking bulk.

Under case (*a*), where bulk is broken at the dock front, the unloading is done by fixed or traversing hoists or unloaders used only for this operation, while the stocking is done by equipment ordinarily acting independently of the hoists. This stocking equipment is of various types, and the method employed for stocking is again divided into two general classes:

(1) That in which no provision is made for longitudinal transfer of the coal, necessitating its being stocked directly back of the unloading tower, so that boat must be placed opposite the area on which coal is to be stocked.

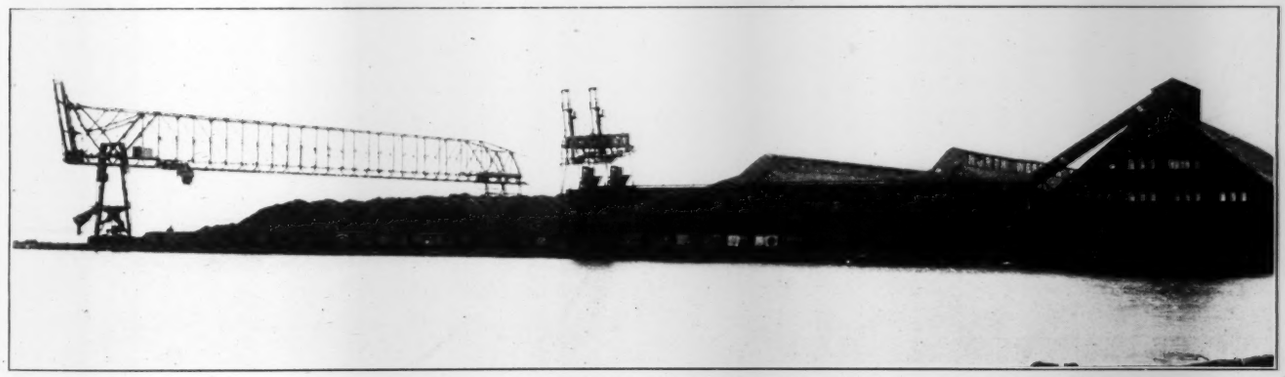


FIG. 28 NORTH WESTERN FUEL COMPANY'S DOCK NO. 1, SUPERIOR, SHOWING ANTHRACITE SECTION AND LARGEST COAL HANDLING BRIDGE INSTALLED TO DATE

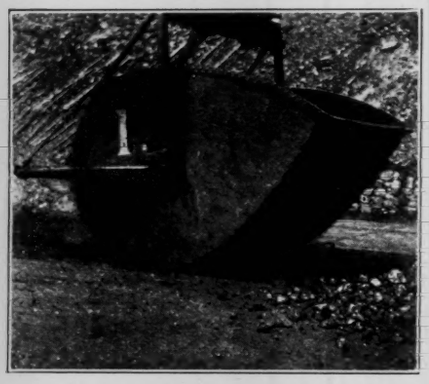


Fig. 29 Brown 7-Ton Stocking Tub on North Western Fuel Company's Superior Dock No. 1

Fig. 31 First Reclaiming Clam at the Head of the Lakes, designed by Fred Barrows. First used at the Ohio Coal Company's Dock in 1888 or 1889

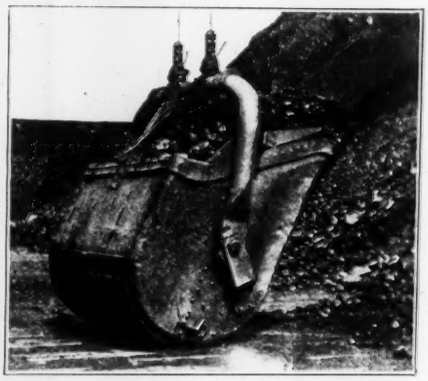


Fig. 30 Brown 4-Ton Shovel Bucket on North Western Fuel Company's Superior Dock No. 1

(2) That by which provision is made for longitudinal as well as transverse movement of the coal in transferring to stock pile, giving perfect flexibility in stocking and enabling the coal to be stocked on any part of the dock desired, regardless of the position of the boats and hoists.

Method (*a*-1) obtained in a few of the earlier plants but has now been largely, if not entirely, displaced by the method designated as *a*-2.

Method (*a*-2) is used in

Plants equipped with transfer cars and stocking bridges

Installations of dump car systems operated either by hand or by cable on bridges or stationary runways

Systems of longitudinal and transverse conveyors

Longitudinal conveyors in conjunction with trolleys, or conveyors operating on transverse runways, or bridges

Method (*b*) comprises

One or more units designated as coal handling bridges on each of which a single trolley is used for the various operations of unloading, stocking, reclaiming and delivering to bins for reshipment by rail

Traversing hoists registering with stationary runways, or combined units made up of fixed hoists in line with stationary transverse runways

Trolleys employed in stocking are ordinarily equipped either with automatic dumping tubs, which are self-righting, or with drop bottom skips.

The reclaiming of coal for reshipment by rail is done by various methods dependent in part upon the method

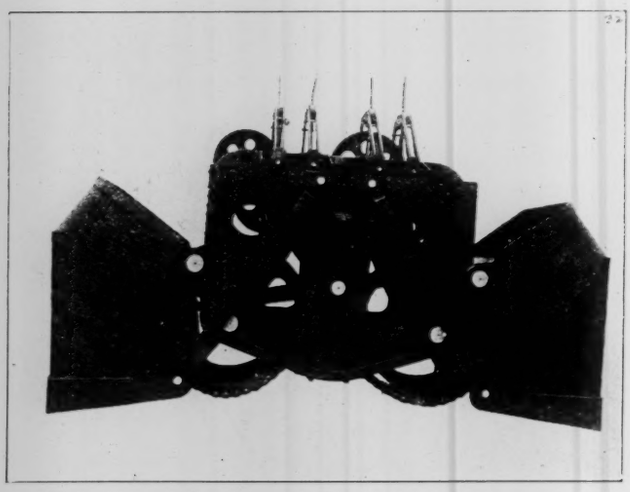


Fig. 32 Hulett 7½-Ton Clamshell Grab Bucket

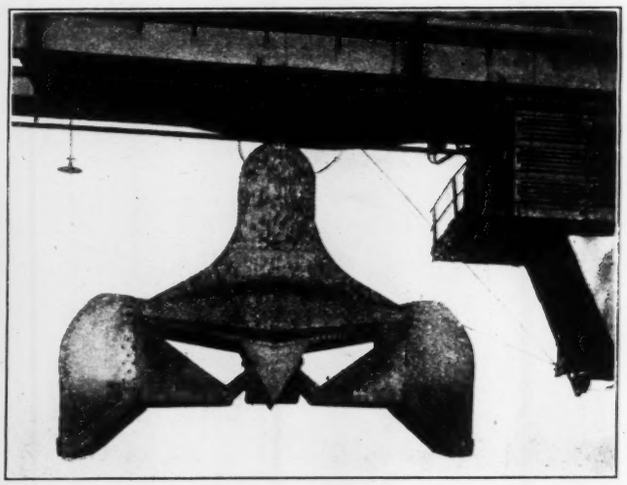


Fig. 33 Heyl and Patterson Man Trolley and 12-Ton Unloading Clamshell on North Western Fuel Company's No. 5 Bridge

employed in stocking. Where the stocking is done by means of trolleys, automatic cars or belt conveyors, operating on bridges or runways, the reclaiming is largely done by trolleys equipped either with shovel buckets or clam-shelled grab buckets, which have practically superseded shoveling to tubs. Where coal is stocked by flight conveyors, the over and under type is used, the reclaiming being done on the lower run of conveyors, which are enclosed in concrete or timber tunnels, running underneath the coal piles.

CLAMSHELL GRAB BUCKETS

On practically all unloading equipment in which the structural and mechanical parts are of sufficient strength to permit, clamshell grab buckets have superseded the tubs formerly in common use. The clamshell, designated as the two-rope type, is ordinarily used on larger installations, while the single rope type is sometimes used in replacing tubs on old hoists, and on some new installations where simplicity of the hoisting mechanism or light weight on the trolley is desired.

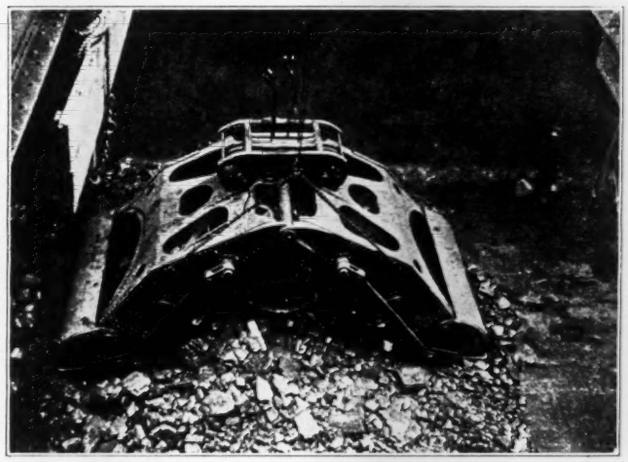


Fig. 34 Heyl and Patterson 4-Ton Clean-Up Clam, installed on North Western Fuel Company's Dock No. 2, in 1912

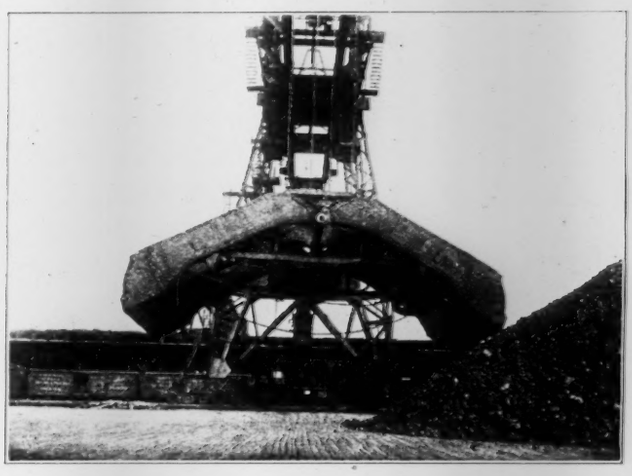


Fig. 35 Heyl and Patterson 6-Ton Clean-Up Clam, 13 Ft. 6 In. Wide, with 24 Ft. Reach, installed on North Western Fuel Company's No. 5 Bridge, Dock No. 1, Superior

The first clamshell used at the Head of the Lakes was invented by Fred Barrows, in about 1888 or 1889, and manufactured under patents of Mr. Barrows and D. B. Smith, both of the Ohio Coal Company, which patents were later purchased by the North Western Fuel Company. This clam was used for reclaiming only. A clam of this type, still in service on the North Western Fuel Company's Duluth dock, is shown on Fig. 31.

The first unloading grab bucket put into service at the Head of the Lakes, was the Newell & Ladd clamshell bucket and was installed on the Duluth dock of the Ohio Coal Company in 1895. The first clam of this type was made by the John A. Mead Manufacturing Company in 1883, and the clams were used to a limited extent in the East. This was one of the first, if not the first, clam to come into general use.

Clamshell grab buckets of several types and makes now in use, are shown on Figs. 32 and 33.

The process of breaking down or the removal of the free coal from the hatches of the vessels at the present time, is done by means of clamshell grab buckets, which open crosswise of the boat, and are of such width as to have sufficient clearance in entering the hatch. Formerly, the coal out of ready reach of the unloading clams was either trimmed to the hatch by hand shoveling for picking up by the clams, or hand shoveled to tubs, and, in some instances, to the clam itself in cleaning up the boat. As this process, however, necessitated considerable intermittent high priced labor, various methods have been devised for cleaning up the boat by mechanical means.

The first equipment, of which the writer has knowledge, in which the cleaning up of the vessels by mechanical means was provided for, was the Hulett automatic unloader designed by Mr. G. H. Hulett, the first installation of which was made at the iron ore docks of the Pittsburgh & Conneaut Dock Company of Conneaut, Ohio, in 1898. In these unloaders, the clamshell, which is of large capacity, was rotated after entering the hatch so as to extend lengthwise of the boat, enabling it to reach the ore tributary to each hatch. These machines had an unloading capacity far in excess of any equipment previously installed, and have been extensively used in the unloading of iron ore at the lower lake ports.

Following the development of the unloader above mentioned, clamshells came into general use in the unloading of both ore and coal, and several devices were tried out with varying degrees of success for scraping or trimming the ore and coal from the wings to within reach of the clamshell, with view to avoiding hand trimming and hand shoveling to tubs in cleaning up the vessels.

In the Brown swiveling trolley developed for this purpose a turntable is provided, which rotates the clam in the hold of the boat, and is used on the recent installations of the Brown equipment on the Nos. 5 and 7 docks of the Pittsburgh Coal Company at Superior and Duluth, to which reference has previously been made.

The Heyl & Patterson clean-up clam is built of dimensions to permit its entering the hatch closed and to open below deck lengthwise of the boat, with a reach of twenty-four feet, covering the entire space center to center of the hatches on each side of the hatch being worked, thus requiring the clean-up clam to be worked only in alternate hatches for boats having hatches spaced twelve foot centers. This clean-up clam, first installed on the North Western Fuel Company's Superior Dock No. 2, has been applied in a considerable number of later installations of both larger and smaller capacity, and in each case is so proportioned as to give the same total lifted load on the trolley as for the unloading bucket (Figs. 34 and 35).

The Mead Company has since produced a clean-up clam of less reach and dead weight, with capacity for proportionately greater coal load.

For the trimmings of anthracite coal within storage buildings in stocking and reclaiming, and for the transferring of bituminous screenings to and from stock piles, steel scrapers, sometimes designated as flying scrapers, were introduced in about 1890. These scrapers are ordinarily worked by means of ropes, for pulling them in opposite directions.

SCREENING

Coal is screened before shipment from the mine and all anthracite and all bituminous coal, with the exception of railroad coal, which is used largely for locomotive firing, is reprepared before reshipment from the dock, care being taken to make the coal of each grade uniform. It is also carefully inspected upon its arrival by vessel; while being unloaded; and during the process of repreparation; each car load is also inspected while being loaded for rail shipment.

Various types of screens are used, choice of type being made to suit kind of coal, the tonnage handled at a single point, and the particular part of the process for which the screen is to be used. When coal is to be loaded out through various openings in long continuous lines of bins, where the tonnage loaded out over each screen is comparatively small, single stationary lip screens are used with good results. This type of screen is also considerably used in the rescreening of the degradation made in the first screening process. For anthracite coal, the screens used are either wire mesh or perforated plate; and for bituminous coal, they are of the bar type. Automatic baffles or retarders are occasionally used for controlling the flow over lip screens, but possibly one of the most effective devices is a flight conveyor of light open construction running over the screen surface at a predetermined speed. This controls the velocity over the screen and insures uniform discharge to the car.

Where, however, large tonnage is to be loaded at central shipping pockets, either mechanical screens or a large bank of lip screens are used. Mechanical screens are of two general types, revolving screens and shaking screens. Revolving screens are provided with one full length inner jacket and one or more concentric shorter outer jackets, and shaking screens are made up either with a single bed or in tiers of two or more beds for the proper separation and distribution of the coal.

RELOADING FOR RAIL SHIPMENT

Three general methods are used in reloading coal to cars for rail shipment:

a That in which coal is loaded out through a long continuous line of bins, with loading chutes or lip screens at frequent intervals permitting the loading of several cars simultaneously. Bituminous coal, under this method of loading, was formerly trimmed in the cars by hand, while the anthracite was, and to some extent still is, trimmed in the cars by the use of telescopic chutes attached to forked aprons at the outer end of the screens. Box car loaders are now used for both kinds of coal.

b That in which the coal is loaded out through central shipping pockets, which is made possible by tilting box car loaders having capacity of from ten to twelve cars per hour or from 3000 to 4000 tons per 10-hour day.

c That in which the coal is loaded out through bins mounted on traversing coal handling bridges or through detached movable screening plants, the coal being trimmed in the car either by portable box car loaders traveling along the dock or by box car loaders mounted on the bridge or screening plant.

As a great deal of the coal is now shipped in box cars, and loading these cars by hand is both slow and expensive, a number of mechanical loaders have at various times been put on the market. The first box car loader[1] of which we have record is that invented by Richard Ramsey of Illinois in 1885. This was manufactured by the Ottumwa Box Car Loader Company and the Litchfield Foundry & Machine Company. Two years later, in 1887, William Ramsey of Iowa invented a loader which was also manufactured by the Ottumwa Company. In 1894, F. W. Bond invented the third loader, which was built by the Litchfield Foundry & Machine Company. The coal was so badly broken and the cars so badly damaged by these loaders, that their manufacture was soon discontinued.

[1] Data relative to early history of box car loaders are taken from a paper read by Wm. L. Affelder, Supt., Mosgrove Coal Co., before the Central Mining Institute of Western Pennsylvania, December 1904.

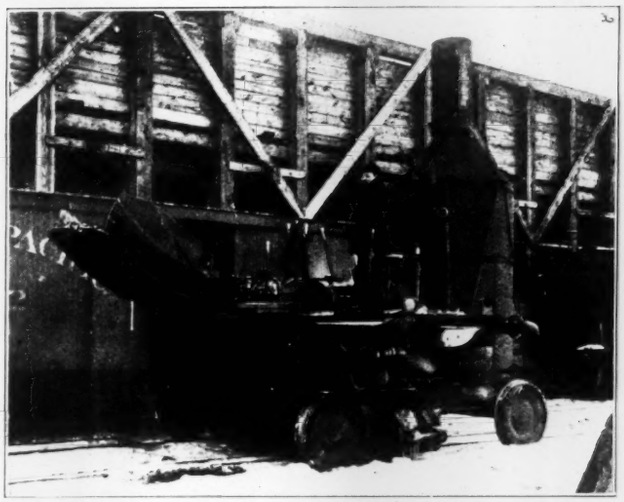


Fig. 36 Ottumwa Steam Box Car Loader, installed on North Western Fuel Company's Dock No. 1 in 1902. First Portable Loader ever built

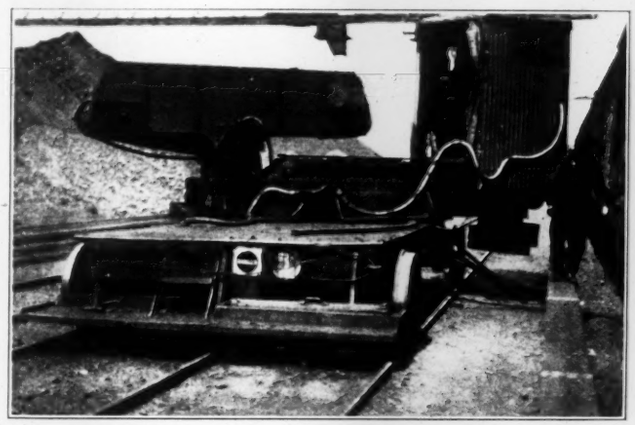


Fig. 37 Christy Box Car Loader Company's Electric Swiveling Conveyor Loader, installed on North Western Fuel Company's Dock No. 1, Superior, 1913

In 1897, the first really successful loader was manufactured by the Ottumwa Box Car Loader Company, although their first loader built two years previously was a failure. In 1898, the first Christy loader, invented by J. M. Christy, was installed in Des Moines.

The following year, the first Victor loader, invented by D. A. Chappell, President of the Victor Fuel Company, Denver, was installed.

In 1900, the Smith gravity loader, invented by S. Kedzie Smith, Civil Engineer in Billings, Mont., was installed for the Northwestern Improvement Company, Roslyn, Wash. This is manufactured by the Dodge Coal Storage Company and the Ottumwa Box Car Loader Company.

In 1902, the Ottumwa Box Car Loader Company developed, at the request of the North Western Fuel Company, and installed on their Superior Dock No. 1, the first portable box car loader. This was a steam loader, equipped with engine and boiler. The following year, the same company, also at the request of the North Western Fuel Company, developed the first electric loader, which was installed on the same dock. Since that time, a large number of electric portable loaders of this make have been installed at the head of the lakes. In the Ottumwa loader, the coal is trimmed in the cars by means of a reciprocating cradle and pusher traveling therein the full length of the cradle, Fig. 36.

During the same period, a large number of Christy portable electric loaders have also been installed on the docks in Duluth and Superior. The distinctive feature in this loader is the use of a steel lagged conveyor for trimming coal in the car, the speed of the conveyor being under control to suit conditions of loading, Fig. 37.

In 1906, a Smith tilting box car loader was installed on the North Western Fuel Company's Dock No. 1 by the Dodge Coal Storage Company, with rated capacity

Fig. 39 Manierre Conveyor Loader, mounted on Bridge Pier, Carnegie Coal Company's Dock No. 2, Duluth

Fig. 38 Smith Tilting Box Car Loader, built by the Dodge Coal Storage Company

for handling 100 cars or 3000 tons of anthracite coal in ten hours. This loader tilts the car endwise on the cradle, which permits the flow of coal alternately to each end of the car by gravity. After the two ends are loaded the car is brought to level position and the middle of the car filled without hand trimming. This type of loader permits the loading of a large tonnage at a single central point, and is used for handling both anthracite and bituminous coal. Smith loaders have since been installed on the Philadelphia & Reading dock in Superior and the Carnegie No. 2 dock in Duluth, Fig. 38.

For the purpose of handling bituminous screenings, there was installed on the North Western Fuel Company's No. 1 dock in 1909 a Fairmont centrifugal loader, manufactured by the Fairmont Mining Machinery Company, of Fairmont, W. Va. In this loader the coal is received by a cylinder, from which it is discharged by blades attached to a rotating head.

Two other types of loaders have recently been developed in Milwaukee, one of which, the Manierre loader, is adapted for handling both bituminous and anthracite coal. The Hanna Coal Company installed two of these loaders in 1912 for handling anthracite. Since then, three loaders of this type have been installed on the bridge piers on the Pittsburgh Nos. 5 and 7 docks for handling bituminous coal, and a fourth loader for anthracite has been installed on No. 7 dock. This is a stationary type of loader, located on the same side of the car as the loading bin, as shown by Fig. 39. The distinctive feature of this loader is the swinging supporting arm, to the outer end of which the conveyor is pivoted. This permits conveyor being extended alternately into the opposite ends of the car, allowing low conveyor speed in unloading.

In 1911, the other type of stationary anthracite conveyor loader was designed by Mr. John Ecks, Chief Engineer of the Milwaukee-Western Fuel Company, and was installed on one of the docks of this company, for loading anthracite coal to box cars on two tracks, between which it is located. The distinctive feature of this loader is the reciprocating motion of the belt conveyor, permitting it to travel toward the end of the car for reducing throw of the coal to the minimum, thus permitting low conveyor speed.

The following year, one of these loaders was installed for loading anthracite coal at the North Western Fuel Company's Superior Dock No. 1.

With the exception of a few of the earlier steam loaders, the portable loaders thus far installed have been electrically operated. At the present time, however, a Christy "Superior" type loader is under construction for the North Western Fuel Company's Superior Dock No. 2, in which a gasoline engine will furnish power for the travel of the loader along the dock.

Portable loaders serve not only for loading coal, but also for the switching and spotting of loaded and empty cars.

To expedite loading operations, the spotting and local switching of cars, when not done by the portable loaders, is usually done at the receiving docks by one of the several types of rope haulage or carpuller systems. Gravity tracks are also frequently used where conditions make it desirable. At the car dumpers at the lower lake ports it is customary to run the cars down grade from the storage tracks onto a kick-back track, after which they are run onto the cradle of the car dumper by means of a small car attached to a haulage rope, variously designated as a ground hog, mule or pig.

Cars are weighed before and after loading on railroad scales of from 100 to 150 tons capacity. Both the overhead and pit types of scales are used and are ordinarily provided with dead rail. Automatic scales are used to a limited extent, and where this type of scale is not in use, the scales are of recording or registering beam type, which enables the weighmaster to retain a ticket for each car, with the net and gross weights stamped thereon, corresponding to the position of the poise, thus avoiding the possibility of error in writing the weights. The weighing in Minnesota and Wisconsin is done by the Western Railway Weighing Association. Every precaution is taken to insure accuracy in weighing, and the scales are given frequent attention and are regularly inspected by the dock companies. Periodically, inspection and tests are made by the state scale inspectors, for which purpose a special test car is used. The scales at the retail yards for weighing coal delivered by auto trucks and wagons are given the same attention. Both the track and wagon scales are balanced frequently during the day, while in service. Smithing coal, which is sacked for shipment in comparatively small quantities, is weighed on wheelbarrow scales during the process of sacking, prior to taking total weight on wagon or track scales.

Conveyor weighers, by which the weight of the coal being handled by belt conveyor is obtained automatically by electrical device, have been in use for several years to a limited extent by purchasers of coal and other bulk material, and also for check weighing, but have not thus far been used on the coal docks at the receiving ports for determining shipping weights.

CONDITIONS RELATING TO THE HANDLING OF COAL

In the handling and storage of coal, numerous precautions are necessary in order to avoid undue breakage or degradation. It is necessary to break bulk as few times as possible in handling the coal from the time it leaves the boat until it is loaded to cars for reshipment by rail. With the same end in view, it is also necessary to limit the free fall of the coal and the velocity of the flow as much as practicable. In compliance with above conditions, coal handled by clams or other buckets should be lowered to pile or bin before being discharged. An ideal device for lowering anthracite and other small sized coal vertically, where

the drop would be large, is the Humphrey type of shelf lowering chute, which consists of a vertical shaft, in which the shelves, placed alternately on opposite sides, are so arranged that the coal flows over itself at a uniform moderate velocity, regardless of the distance through which the coal is lowered. Where it is desired to lower and also convey the coal horizontally by gravity, step chutes built on similar principle are employed to advantage.

The deterioration of bituminous coal in storage is slight, and recent experiments show it to be less than it is commonly supposed to be. Anthracite coal is not subject to any appreciable deterioration even though stored out of doors, but to supply the demand for bright coal it is housed in buildings for protection from the weather.

The liability of bituminous coal, especially screenings and some grades of run of pile, to spontaneous combustion, has made it necessary to limit the height of pile to suit the available rehandling facilities, as the first step in handling a coal fire is to get direct access to the fire by rehandling the hundreds, and frequently thousands, of tons of coal within the inverted cone tributary to the small area at the bottom of the pile, where the fire starts. It is sometimes also necessary to isolate the burning area to prevent the fire spreading. After the fire is uncovered, it can be extinguished by the use of water and the rehandling of the smoldering or burning coal. The application of water, however, to the top of the original coal pile is ordinarily useless and frequently increases the fire. While the liability to spontaneous combustion cannot be entirely eliminated, a clean dock surface and the absence of combustible foreign matter within the coal pile, and, after the coal is in storage, careful watching and prompt rehandling upon the first indication of heating, reduce the liability to a minimum.

Another essential condition, which is being complied with in an increasing degree, is the safeguarding of employees by the provision of sanitary conditions

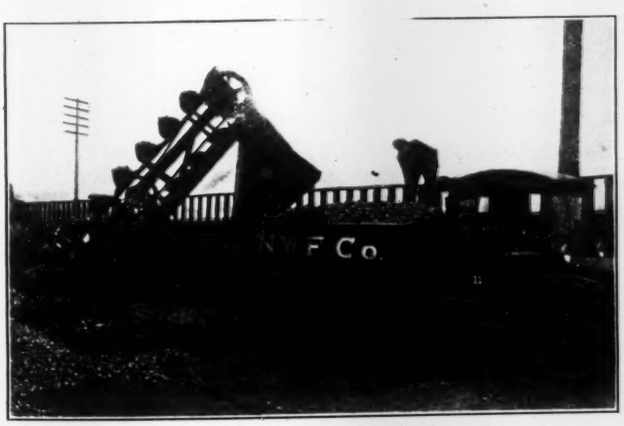


Fig. 40] Specialty Engineering Company's Wagon Loader, North Western Fuel Company's Yard No. 1, St. Paul, 1914

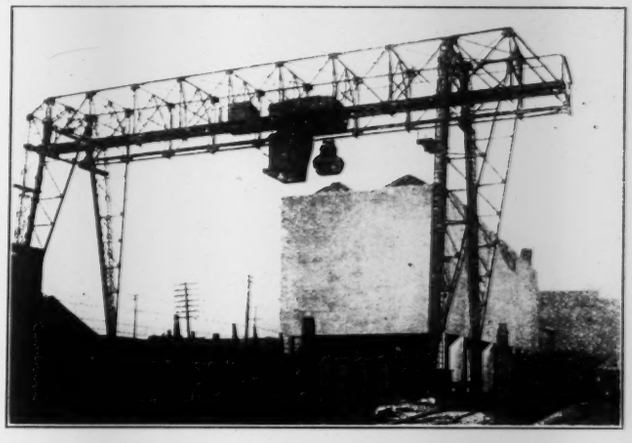


Fig. 41 McMyler Mechanical Plant for Retail Yard Cleveland and Pittsburgh Coal Company's Retail Yard, Cleveland

and the application of safety appliances to the dock equipment. For the removal of coal dust from enclosures where it is produced in unusual quantities, dust exhaust fans are being introduced for the benefit of employees and to facilitate operations.

The use of electric power in place of steam, which was common until twelve or thirteen years ago, has several very marked advantages. Electric power can easily be distributed, with comparatively small loss, to various remote centers on movable equipment. Branch lines can readily be cut out when not in service, and there is slight loss from leakage in feeders whether the motors are in operation or idle. Other advantages are the control of motors by means of magnetic switches and master controllers, and the ease with which automatic safety devices can be introduced for safeguarding operations of hoisting and lowering of bucket, and traversing of man trolleys and bridges. Dynamic braking is also a valuable feature in man trolley operation, where the loads are heavy and high speed is attained. Probably the greatest disadvantage in the use of electricity in place of steam is the absence of steam for heating purposes, as, while the use of electric heaters is feasible, the cost is excessive. In hoisting operations, current fluctuations are excessive, owing to peaks incident to accelerating and to intermittent operation of the individual units. When conditions warrant, provision is made for equalizing the load on the generating plant by the installation of motor-generator flywheel set or storage battery.

The handling of coal in retail yards is another important branch of industry. The most of these yards simply have covered sheds, into which coal is unloaded from cars and from which coal is loaded into wagons and auto trucks by hand shoveling. Where the volume of business warrants, however, elevator and conveyor installations for unloading and stocking coal in sheds and bins are coming into more general use, and electric portable wagon loaders, shown on Fig. 40

for taking coal from storage pile at ground level and loading to delivery trucks are being more generally used. An increasing number of plants are being installed for mechanically performing all the operations at retail yards of large capacity, with three to five ton auto trucks for long hauls, Fig. 41.

The non-occurrence of high grade coals in this section of the country, and the high cost of delivery by rail incident to long haul, make of vital importance careful consideration of the subject of cheap lake transportation, and the development of mechanical equipment which will at low cost, and with dispatch, load, unload, and deliver to the consumer the large and rapidly increasing tonnage of coal required for distribution throughout the northwest.

The writer wishes to acknowledge the courtesy, which has been extended in furnishing information for this article by the management of the various coal companies and by the manufacturers of the equipment herein described.

MINNEAPOLIS FLOUR MILLING

BY CHAS. A. LANG, MINNEAPOLIS, MINN.

Junior Member of the Society

IN the popular mind, the word flour is as intimately associated with the name Minneapolis as steel is with Pittsburgh. The first manufacturing enterprise in Minneapolis was a government grist mill built in 1823 by Colonel Snelling from whom Fort Snelling derives its name. He sent, under Lieutenant McCabe, a detachment of fifteen soldiers to the west bank of the Falls of St. Anthony and on the site of the present mill "D" of the Northwestern Consolidated Milling Company, the first mill was built. It was a crude affair about 20 ft. square, built of logs and containing one pair of mill stones. The power was derived from a log flume from the crest of the Falls, discharging into a flutter wheel at the mill.

From such a beginning has the present milling industry and its allied interests grown. The potential possibilities of the Northwestern territories for the production of wheat was, at that time, undreamed of. The water power was evident and gave the first incentive for the building of grist mills and lumber mills at Minneapolis. The supply of wheat in that time was the most serious handicap. The fitness of the soil in the immediate vicinity for raising wheat was not known. The soldiers at the time of building the first mill tried their hands at raising wheat and as very light crops resulted, they were soon discouraged and gave it up. This first mill ceased grinding wheat about four years after being built.

This seemed to be the end of flour milling, for nothing was heard of the government mill until about 1849 when the town of St. Anthony was established on the east side of the Falls. The first court ever held in Hennepin County convened in the old mill in 1849. The mill was apparently the only place available at that time for court sittings. It is a far cry from a grist mill to a court of law, and serves to show how close was the connection of the flour mill with the early history of the settlements which were to form the future city of Minneapolis. The west side of the river at the Falls was still a government reservation. Upon this ground now stands what is known as the milling district and is the center of the flour manufacturing industry in Minneapolis.

The history of the various mills as they were developed from the time of the old government mill is too long a story to go into at this time, covering as it does, a period of some 80 years. This history in itself covers practically every development and invention that gave rise to the present system of American milling. It is not a record of success in every venture, for mills were destroyed by flood and fire and rebuilt in continuously increasing size and completeness. Some men made fortunes and others failed. With them all there was the belief that Minneapolis would be a great milling center. Transportation facilities were crude and uncertain; the difficulties of getting the grain to their mills and their product to the markets of the world made many give up the field. Mills were dismantled, built and rebuilt to take advantage of some newly invented system of milling, and money was spent with a lavish hand to improve the quality of their product over that of their competitors. It became a question of the survival of the fittest. One mill would receive a shipment of machinery and try to hide the fact from the other mills. The mill would be closely guarded while this new machinery was installed and operated. It would be but a short time before one of the employees would go to some other mill and the secret become common property. There is no doubt but that this keen rivalry between the various mills in raising the standard of the product of all the mills, gave Minneapolis its standing to the point where Minneapolis Patent Flour is the standard by which all are judged.

The great mill explosion of May 2, 1878, which destroyed the Washburn "A," Pettit, Galaxy, Humboldt, Diamond and Zenith Mills, threatened to bring Minneapolis milling to a sudden end. Instead of that,

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the industry was many times strengthened by new and better mills erected on the site of the ruins. In the new mills, the mistakes of the past were corrected and the possibility of a second dust explosion greatly lessened by the use of air suction systems for removing the dust as it was created in the machines and before it could fill the air of the mill. This great explosion occurred in the Washburn "A," and was so violent that it is said that hardly one stone was left on top of another. The walls of the surrounding mills were wrecked so that the fire, which followed, quickly completed their ruin. A second fire occurred in 1881, which destroyed the Pillsbury "B," Excelsior, Empire and Minneapolis Mills, the latter exploding as a result of the fire. The rebuilding of these mills marked the passing of the old milling district.

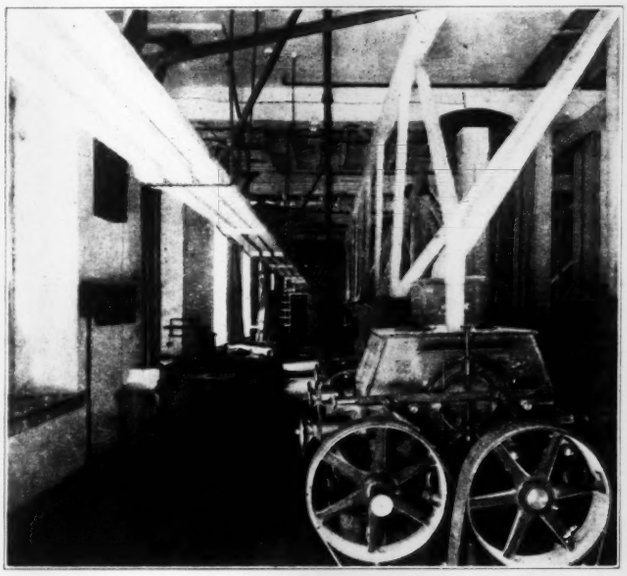

Fig. 1 Roll Floor

From that time up to the present, the operations have been more in the increasing of capacity and the improving of milling systems than in the building of new plants. The larger companies have improved their grain handling facilities by the building of large terminal elevators in connection with their mills. This grain storage assures a uniform supply of the various grades of wheat and puts it in the proper condition for delivery to the mill. The building of these elevators as well as the increase of capacity of the mills, called for increased power. To meet this condition large central steam power stations have been built and hydraulic turbines of increased power and efficiency installed, so that in the present milling district is seen some of the most modern and up to date power apparatus that the market affords. As an example, at the present writing, there is being installed by two milling companies, two pairs of 42-in. hydraulic turbines of 1800-h.p. capacity, to have in their settings a guaranteed efficiency of 87 per cent. All of the larger mills have their water power supplemented by steam power or electric motors driven from the central steam stations. Where formerly each mill had its individual

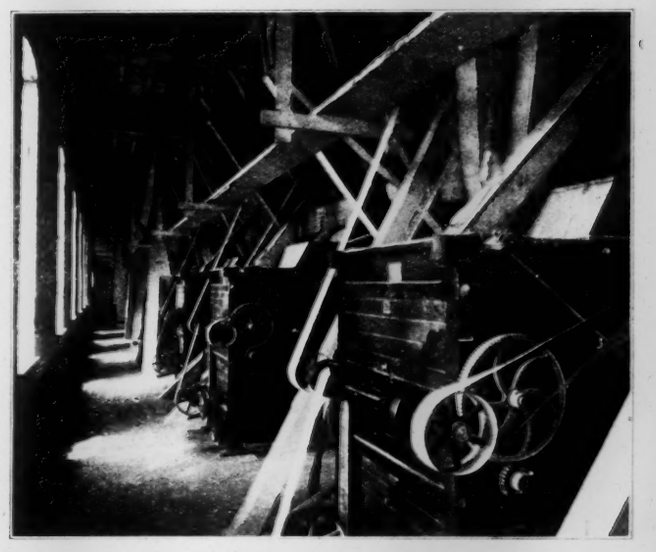

Fig. 2 Purifier Floor

steam plant for relay, most of these have been abandoned in favor of the electric drive from central stations. The consolidation of the various mills into the present three large companies made it possible for each to centralize its power.

The present capacity of the Minneapolis mills is 84,000 bbl. of flour every 24 hours. There are 23 mills,

Fig. 3 Sifter Floor

which makes the average capacity 3600 bbl. per mill. The largest mill in the world, the Pillsbury "A," has a record of having made 16,125 bbl. in one day, although its capacity is rated at about 11,000 bbl. The

mills vary in size from this to experimental mills of a few hundred barrels capacity. Flour mills run 24 hours a day, sometimes for many weeks without stopping. The usual running time is from Monday morning to the following Sunday morning.

THE MINNEAPOLIS WATER POWER

The Falls of the St. Anthony have played so prominent a part in the development of milling in Minneapolis, that they deserve special mention. The present developed power is approximately 60,000 h.p. under an average fall of 47 ft. This power, with the exception of 12,000 h.p. in the Hennepin Island station used by the Street Railway Company, is practically all taken by the flour mills. The races from the mills and this island station discharge into the pond of what is called the Lower Dam. This gives another fall of 18 ft. and is used entirely in a second plant where 10,000 h.p. is generated for use of the Street Railway Company. The Hennepin Island Station is an excess plant and is run only when the demands of all other users of power are satisfied.

The unit of measurement is the mill power defined as 30 cu. ft. per second under a fall of 22 ft., or approximately 75-h.p. gross. The mill powers are numbered from 1 to 48, there being in many cases several having the same number. Under conditions of limited water supply such as occur in the winter months, the mill powers are cut off in the inverse order of their priority number. This is, Series No. 48 would be taken off first and so on down until a balance was reached between the available supply and the amount used. It is under such conditions that the steam relays have to be used. Early in the history of the mills, these mill powers were owned or leased by the various mill owners in proportion to the power they used, and the water power company was something in the nature of a coöperative organization. The rental of the early powers was but nominal, which gave so little for dividends that free powers were given instead. These free powers and also the leased powers are perpetual and non-assessable. As the value of the power began to be appreciated, the rental increased when new leases were made to where $1000 per year was charged for Series No. 48.

In the water power development of the main falls, there is nothing that could rightly be called a dam. Underlying both sides of the river and the falls, is a limestone ledge which is about 12 ft. thick on the downstream edge, and which tapers in thickness as it extends up stream to where it stops some 1200 ft. above the Falls. In fact, it is like a shingle with its thin edge lying up stream. The downstream edge of the ledge is in the form of a great hollow square or horseshoe whose sides extend down stream. At the upper end of the hollow square in the center, is the spillway. This is an apron which protects the face of the ledge and slopes from the top of the ledge to the pool below. Starting from either end of the apron, extending up stream and built on top of the ledge in an elongated U shape, is a dam which gives a depth of water of 14 ft. above the ledge, forming the mill pond, from which the water is taken in canals to the mills. The water spills over this dam on to the ledge and down over the apron. From ends of the apron and forming a continuation of the dam, are walls built on top of and following the edges of the ledge downstream. These walls form the river side of the main head races to the mills, one on either side of the river. The mills on the river side of the head race have their front walls built on the wall of the canal and their back walls extending down to tail race level, making them some three stories higher in the back than in the front. These mills take their water supply through penstocks and the water-wheels discharge directly into the main tail race. The mills on the other side of the head race take their water through canals from the head race into open flume waterwheel settings. These wheels discharge through holes cut through the ledge. From these wheel pits tunnels are cut under the ledge to the main tail race. The formation below the ledge is a tightly compressed white sand which just misses being sandstone, and it is through this that the tail races are cut. Most of these races are lined with concrete or brick up to the ledge, the ledge making the roof.

The water power development in its present state was not reached without as many serious mishaps as befell the mills in their evolution. The earlier retaining walls and canals were timber and crib structures, and there were many wash-outs, even carrying entire mills away. In 1870 the most severe wash-out occurred. Through a break on the east side, almost the entire river ran under the ledge, and it looked as if the Minneapolis water power were a thing of the past. It was then that the federal authorities were called upon for help. Congress appropriated over half a million dollars, and with this a dike or cut-off wall was built across the river under the ledge.

In the early days there was no attempt made to maintain a uniform head of water by limiting the amount each mill could use. When the water was low it was just a grand scramble to see who would get enough to keep their mill running. Stories are told of how, when there would be but two or three feet of water in the canal, the crew in one mill would build dikes of sand bags and boards to divert the water into their wheel pit. Then the crew from the mill below them would try to tear out the dike so they could get the water, and a fight would ensue with material damage to the heads of the party having the smallest number of picks and shovels. The power on the east side of the river was controlled by the St. Anthony Falls Water Power Company, and on the west side by the Minneapolis

Mill Company. While these two companies still exist, they are now under the same management.

THE MILLING PROCESS

Probably the oldest known mechanical process is the reduction of seeds or grain to meal. The prehistoric man may have had a loom for weaving his cloth, but he did not leave one for us to see. He did leave us the hollowed out boulder to testify to the fact that he ground his wild seeds that they might be made more suitable as food for human beings. He discovered the fact that his digestive apparatus was not effective in penetrating the outer protective coating of the seeds so that the meat within might be assimilated and give him strength. His mental processes may have been as crude as his time, but they were concerned chiefly in getting food and clothing—mostly food—and he seems to have solved the problem for many following generations.

For centuries the mortar and pestle were the mills for the grinding of grain. It is still used in the less civilized countries. Then came the stones which were too large to be easily used by hand and were turned by animal or man power in treadmill style with a long sweep attached to the upper stone. The French Buhr stone of the present day is the same idea except that the upper stone is driven by a vertical shaft which passes down through the hole or eye of the lower or stationary stone. This type of mill is not entirely obsolete but is used in some of the present day mills for finishing certain of the purified streams or middlings.

In 1839 came the next step when cast-iron rollers began to be used in Budapest. The first successful machine used there was the Sulzberger cast-iron roller machine. About this same time the Hungarian millers began to use the gradual reduction process which came to be known as the Hungarian process. The term Hungarian process is misused when it is given to cover the use of chilled iron rolls, and such is often the case. This process can be carried out on Buhr stones as well as on rolls.

The next improvement was the purifier which was developed in Minneapolis, and is distinctively an American contribution to milling, although some attempts had been made in France to use such a machine. The purifier is a machine which in simple terms can be described as a reciprocating sieve over which passes certain of the streams of mill stock and through which is drawn a current of air which removes the dust that would cause discoloration in the finished flour.

The old-time method of making flour was to reduce the wheat berry in one grinding operation to as nearly the fineness of the finished product as was possible. That part of the bran or husk which was not at the same time reduced to an equal fineness to the flour, was removed by sifting. The flour obtained by such a process was inferior in color, containing as it did a large percentage of finely ground bran and dust from the crease in the wheat berry.

Fig. 4 Milling District from West

The Hungarian, or gradual reduction process, is the system in which the wheat passes through numerous grinding operations in series before its final reduction to flour. The first grinding operation, or first break, as it is called, lays the berry open. The next or second break, cuts off some of the inside of the berry left exposed by the first break. The third break takes off some more, and so on to the fifth and final break where nothing but the bran is left in its familiar flattened condition. The pieces of the inside of the berry cut off by the break rolls, are called middlings and are what are finally reduced to flour. The middlings are passed over the purifiers and the dust caused by the grinding is removed. Dust cannot be removed from the flour, and therein lies the advantage of the gradual reduction process in producing clean,

white flour. The term cut is used in describing the action of the break rolls, as these rolls have knife-like corrugations on their surfaces, and actually do cut rather than grind.

The color of finished flour, aside from its being free from impurities, is obtained by granulation. A piece of glass reduced to powder is pure white. This is because the light which it reflects is broken up by the facets of the minute particles. So it is with flour. The inside of the hard spring wheat berry is an opaque, flint-like substance, slightly yellow in color. When reduced to the fineness of flour, the more granular or sharp the particles, the whiter the color.

Fig. 5 Milling District and Falls from East

The wheat from the different sections of the country tributary to any mill is by no means the same in characteristics or quality. Again the wheat grown on a certain piece of land this year, will in its milling value or strength, be very different from that grown last year, even though the same seed be used. The quality of the wheat is a variable but the quality of the flour must be a constant. The color of the flour must be the same this year as it was last year; the gluten must be of a certain percentage and quality, and its ability to absorb water must not vary. The modern mill has a well-equipped laboratory, and it is here that the various kinds of wheat are tested as to their value for making flour. A large part of the available supply of wheat may be inferior in color or low in gluten. A stronger wheat must be found to blend with it, that the product may be uniform.

The various kinds of wheat are delivered to the mill elevator loaded in bulk in box cars. These cars may come from the large terminal grain storage elevators or directly from the small farmers' elevators that are scattered along the lines of railroads that tap the wheat producing country. The wheat is taken out of the car by power shovels and drops through a grating into a receiving hopper. From here it is elevated to the top floor of the elevator and discharged into a garner which is large enough to hold the contents of the largest car, or about 2,000 bu. The garner opens into the hopper of the receiving scale, and the car load is weighed in one draft. The wheat then falls into what is called a receiving separator which is a machine having a number of reciprocating sieves of perforated metal. This removes the coarse refuse such as pieces of wood, coal, iron ore, straw joints and even an occasional Ingersoll watch. It is then ready for storage and drops on conveyor belts which discharge directly into the storage bins. This wheat having been inspected and graded before unloading, is carded to go to bin No. 20, for instance. Bin No. 20 contains wheat of the same grade or of the same value for milling purposes. The advantage of a large mill elevator lies in this ability to take care of many kinds of wheat and store them in quantities that insure a uniform mixture.

In the basement under the storage bins is a conveyor belt having spouts leading to it from the bins. By means of graduated slides in these spouts, a predetermined percentage of wheat from any bin may be drawn on to the conveyor. A number of bins may be drawn upon in this manner to get a wheat mixture that is right for milling. The mixing conveyor discharges into an elevator which takes the wheat again to the top of the elevator where it passes through another weighing process on its way to the bins in the mill proper.

This wheat is still far from being in condition for grinding. Every bushel contains from one to two pounds of foreign seeds, such as oats, cockle, mustard, grass, flax, etc. These are removed by passing over numerous sieves in the milling separators. These seeds, after the removal of the mustard, are pulverized and sold as stock food or ground screenings.

The next step is the cleaning process. There are two different methods in use, the wet and the dry. In the wet process the wheat, together with a stream of water, passes into a washing machine, or "whizzer." This machine has a rapidly revolving cylinder which violently agitates the wheat in the flowing water. As the wheat passes further along in the machine, the water, together with the impurities, is thrown off by the centrifugal force, partially drying the grain at the same time. The wheat has to be dried further by dropping through large cylinders having baffles to retard the flow, while hot, dry air is blown upward through the cylinder, thus completing the drying. The dry process cleans the wheat by dry scouring many times in series. The scouring machines used have cylinders made up of chilled iron plates having very narrow openings or vents. Inside of the cylinders are rapidly revolving paddles or beaters that keep throwing the wheat against the cylinder. At the same time a strong current of air is drawn out through the

vents in the cylinder, which removes the dust and material that is scoured off the wheat. Each machine gives nine separate scourings and four or five machines are used in series. This scouring is so complete that the outer coating of the bran and the " beard " of the wheat is removed, yet the berry is not broken or bruised, but emerges in a smooth, polished condition.

After having had so much air drawn through the wheat, the shell or bran has become dried out and is so brittle that if put over rolls in this condition, this bran would pulverize and become impossible of separation from the flour. To correct this, the wheat is dampened, after which it is allowed to stand for a number of hours in a bin, that the moisture may penetrate the bran. After coming from the bin, the stream of wheat is passed through live steam which still further toughens the bran by driving the moisture in. This is called the tempering process.

The tempered wheat is now ready for grinding and flows directly to the first break rolls where the berry is opened up. The stock then passes to the scalping process, which is the separation of what flour and middlings are made by the first grinding from the bran, which has practically all of the inside of the wheat berry adhering to it. The scalping is done on revolving cylinders of wire cloth called reels, or on large gyrating sifters having a number of flat sieves of wire cloth. As small an amount of flour is made on the first break as possible, as this flour, containing as it does some of the dust from the crease in the wheat berry, which cannot be removed by any washing or scouring process, is inferior in color and must be diverted to the lower grade products. This applies to practically all of the flour made on the break rolls.

The first break stock after scalping, passes to the second break rolls. It is on these rolls that a large amount of middlings are made. This stock is treated to remove the middlings and flour in the same manner as that from the first break, after which it passes to the third break. The process is continued to the fourth and fifth breaks when all of the inside of the berry has been removed from the bran. The bran then goes to a machine called a bran duster which removes what flour has adhered to it. The bran duster is somewhat on the same principle as the wheat scourer, except that soft brushes are used instead of paddles or beaters, and the cylinder agaiinst which the bran is brushed, is of wire screen. This finishes the bran so far as the milling process is concerned and it is ready to pack out.

The middlings made by the break rolls vary in size from that of a coarse quartz sand to a fineness that is hardly different from that of finished flour. These middlings are graded or sifted into six different sizes, so that each resulting stream contains granular particles of practically the same size. This sifting is done through wire or silk gauze having very accurately spaced meshes. These streams of graded middlings then pass to purifiers where strong air currents are drawn upward through them as they pass over the sieves, the meshes of which are of a spacing that does not permit of the granular particles falling through. The coarser middlings then pass to reducing rolls having finer teeth or corrugations than the break rolls, these corrugations being still finer for the smaller sized middlings. The action of the reducing rolls is still a cutting action, it being the idea to make finer middlings of coarser, and not to make flour in the process. From these rolls the grading and purifying process, followed by further roll reduction, is continued until all the streams of middlings have been reduced to very nearly the fineness of flour.

The final reduction of middlings to flour is on smooth rolls where the action is more truly a grinding one. The stock passing to these rolls is so very fine grained that this action extends still further the granulation process and instead of flattening or rounding up the particles, the flour obtained is sharp and granular. Not all of the middlings are reduced by the first passage through the smooth rolls to the proper fineness for flour, so the stream must pass again to a reel where the finished flour sifts through the silk cloth covering and the middlings that are separated out, sent again to the smooth rolls for reduction. This process is continued until all the stock is dressed or sifted to flour. From wheat to flour there are about 21 reductions in the process.

The second grade of flour made in the process is called " bakers " or first clear. This is composed of the cleaner flour from the break rolls and part of the flour made in the reduction of the middlings, including that taken out of the middlings by the air purifying process. This flour is not as white as the First Patent and while high in its percentage of gluten, this gluten does not have the expansive power of that in the Patent Flour. The expansion of the gluten is what makes large, firm loaves of bread, while its quality determines the lightness of the loaf and to a certain extent, its color.

The next lower grade of flour is the Second Clear, and is made up of all the rest of the by-product flour that is " clear " of fine particles of bran. Every machine in a mill, roller mills, bolters, purifiers, reels and elevators, has an air suction connected to it. This suction system yields a large part of the lower grade by-product flour.

The next product is known as " Red Dog " and consists of that part of the flour which contains very small particles of bran that cannot be separated from it. It is the dividing line in the mill products, being a mixture of flour and bran.

Then comes the " Shorts " which consists of finely divided particles of bran. While it is the idea in milling to keep the bran intact, there are many small par-

ticles broken off in the process. The ones that are large enough to be sifted out, go to shorts.

A great many adjustments in milling machinery are provided for. Slides and valves in the spouting enable various streams of mill stocks to be combined or divided at will, or switched from one machine to another. There is a continual changing of the flow of a mill that the flour may be uniform. On a damp, rainy day, the flour absorbs moisture and does not bolt or sift through the silk cloths as freely as on a clear, dry day. At least once an hour, the flour is tested by wetting a sample and comparing with a standard sample which is of unvarying quality. The wetting emphasizes any tendency to change in color. It may be that the test shows that some of the stock going to the First Patent should be diverted to the second grade or Bakers, and a change in the flow is made accordingly. If the stock bolts too freely, the flour will be too coarse. A reel having a light load bolts more freely than one having a larger stream passing through, and the tendency to coarseness in the flour must be corrected by shifting a larger stream to the lightly loaded reel. Aside from these tests made in the mills, the mill laboratory plays an important part in keeping the product uniform. In companies having several mills, samples are taken every day of the run of each mill and baked into test loaves of bread. The millers from the various mills come together at bake room time and judge the bread according to size of loaf, texture and color. This keeps the flour from each mill in the group the same as that from the others. At the same time are seen samples of the gluten with its percentage, samples of dough which is another guide to color and test for moisture in the various mill products. Tests for ash which give the mineral salts content are made in retorts. This is another indication of the strength of the wheat and expansion of the gluten. In fact every possible test is made that leads to a complete knowledge of wheat and mill products. Modern American milling in its highest development is a scientific process and not guess work as was the older process. Absolute uniformity of product is assured whether made in one mill or several.

It may not be out of place to give some idea of the power necessary to drive a flour mill. With 1000 h.p. the average modern mill will make 2500 bbl. of flour per 24 hours. This gives a power consumption of a little less than 10 h.p.-hr. per bbl. Taking 1000 h.p. as a basis, there is one mill in this country that makes 3500 to 4000 bbl. or a power consumption of 6 h.p.-hr. per bbl. Another mill makes 1200 bbl. with the same power. These two mills may be called the extremes. The first mill has power transmission machinery that cannot be excelled by any manufacturing plant, and the mill building is of steel and concrete which assures perfect alignment of shafting. The second mill is a freak in that it has two or more times the amount of milling machinery than another mill of the same capacity would have. As the friction load is 38 to 40 per cent of the total, perfection in the transmission machinery or the amount of mill machinery are, very largely, the deciding factors in the power efficiency of the mill.

In the average mill, the distribution of power to the various classes of machinery is as follows:

	Per Cent.
Wheat cleaning	35
Smooth rolls	25
Breaking and middling rolls	14
Bolting, purifying, etc	26
	100

This includes the transmission and friction losses including that of the machines themselves.

Flour mills, in general, are driven as a unit from a single source of power. The process from start to finish is a continuous one, and the various streams must not be stopped. If troubles occur through breakage of machinery the entire mill must shut down, else the choking up of spouting and machines would cause more delay than the accident itself. There are a few mills having group drive by motors where the roll floor is driven by one motor, the bolting machinery by another, etc. With such a drive, remote push button control is necessary to stop and start all motors at the same instant to prevent choking. Aside from this an interlocking system on the trip and no voltage release coils should be used, so that if one motor were cut out by an overload or no voltage, all the motors would be released at the same time. The advantage of such a system over unit control is doubtful. The grain-machinery in the storage elevator and the flour packing machinery is very often used with individual drive.

A flour mill offers almost ideal conditions for cheap production of power. The load is uniform and steady, so that the load factor is practically unity.

The writer is indebted to the Northwestern Miller for facts relating to the history of milling in Minneapolis.

REPORTS OF MEETINGS

MILWAUKEE MEETING, MARCH 21

The second joint meeting of the technical societies of Wisconsin was held in Milwaukee on March 21, 1914, with a very large attendance, about 500 being present at the morning session and 700 during the afternoon and evening. Wm. George Bruce, secretary of the Merchants and Manufacturers Association of Milwaukee, delivered the opening address. Alfred O. Crozier presented a paper on Cement and Clay Products Contrasted. He was followed by Prof. R. C. Disque, who spoke of the Historical Significance of the 1907 Wisconsin Law for the Regulation of Public Utilities, which was the first significant attempt to treat the problem of legislative regulation as a two-sided question. Professor Disque traced the history of such regulation and described in detail the various points of the law passed.

Dinner was served at noon, A. A. Gray addressing those present. At the afternoon session, papers were presented on Principles of Illumination, by John Hayes Smith; Principles of Street Lighting, illustrated by slides, by Arthur J. Sweet and Francis A. Vaughn; Manufacture of Pure Iron Products, illustrated by slides, by G. F. Ahlbrandt; the Measurement of Gases in Large Quantities, illustrated by slides, by J. C. Wilson; Modern Machine Tools, by A. Wood of Lodge & Shipley; and Development in American Power Plant Machinery, illustrated by slides, by Prof. A. G. Christie.

Following a supper a lecture on Radium was given by Dr. Herbert N. McCoy, which was illustrated by lantern slides.

ST. LOUIS MEETING, JUNE 3

The June meeting of the Affiliated Engineering Societies of St. Louis was held on the 3d under the auspices of the Society. H. R. Setz gave an informal talk on Oil Engines, with special reference to the Fulton-Tosi Oil Engine, in which he discussed the principal engineering problems involved in Diesel engine construction. Mr. Setz restricted himself to the moderate speed vertical four-cycle engine as the type which, by virtue of its unsurpassed reliability in continuous operation, is leading all others. The vast experience obtained with this prime mover in thousands of installations gradually evolved typical constructive elements, which in their main parts were analyzed and explained by lantern slides. Mr. Setz further showed how American conditions could be successfully met without impairing economy or reliability of operation. The economic side of the Diesel engine was touched upon and data produced to show its great possibilities in this country, particularly in the South and Southwest.

CINCINNATI MEETING, JUNE 4

A joint meeting of the Cincinnati Section and the Engineers Club of Cincinnati was held on June 4 at the University of Cincinnati. W. A. Phillis of the National Tube Company, Pittsburgh, spoke on the subject, From Ore to National Pipe. The address was illustrated with motion pictures and Mr. Phillis showed his audience many interesting phases of the manufacture of pipe, such as the mining of the ore, the transportation of the ore to the lakes, the handling of the ore at the docks, the loading of the ore transports, the making of pig-iron at the blast furnaces, the open-hearth and bessemer processes of making steel, the pouring and handling of ingots, the rolling of the ingots into slabs, and the rolling, welding, inspection and handling of pipe.

NECROLOGY

EMIL C. BOERNER

Emil C. Boerner, consulting mechanical engineer for Russell, Burdsall & Ward Bolt and Nut Company, died in Port Chester, N. Y., on May 27, 1914, after an illness of some months duration.

Mr. Boerner was born in Germany on May 23, 1843, and came to the United States at the age of fifteen. His first connection was as an apprentice to Russell, Burdsall & Ward, and at the time of his death he had served the company for fifty years. When he first entered their employ their only plant was situated at Pemberwick and was operated on comparatively small lines. After a number of years spent in the upper shop, he severed his connection to go into partnership with George C. Mertz in the wood planing business. Upon the dissolution of this firm, Mr. Boerner went to Providence, R. I., as a machinist, but after a brief time returned to Port Chester to his early employers.

Mr. Boerner was a designer of automatic bolt and nut machinery.

FRANK L. BUSEY

Frank L. Busey was born in Urbana, Ill., on August 28, 1872, and was graduated from the University of Illinois in 1895 with the degree of B.S., receiving also the degree of M.E. in 1898. He was employed in various engineering capacities in Chicago from 1895 to 1900, and in 1905 removed to Seattle, Wash., to enter the office of a consulting engineer. He returned to Urbana in 1906 as first assistant in the engineering experiment station of the University, resigning in 1911 to become assistant chief engineer for the Buffalo Forge Company, Buffalo, N. Y., which position he held at the time of his death.

Mr. Busey was a frequent contributor to the engineering magazines, writing for the most part on his special subjects of heating and ventilating. He had just completed a handbook on fan system apparatus, under the direction of Willis H. Carrier, which was in the printer's hands when his death occurred at the Battle Creek Sanitarium on June 7, 1914.

GEORGE A. DOUGHTY

George A. Doughty, who died on March 8, 1914, was born in Brooklyn, N. Y., on April 2, 1878, and was educated in the public schools, Brooklyn Polytechnic Institute, and Stevens Institute of Technology. In 1898 he entered the drafting room of the Logan Iron Works, becoming secretary of the company in 1909, which position he held at the time of his death.

He has been identified largely with the design, fabrication and erection of shields and caissons, and with general foundation work in connection with the building of subways and tunnels.

THOMAS HILL

Thomas Hill, vice-president of the Electric Wheel Works, died at his home in Quincy, Ill., on May 27, 1914, after a long illness. Mr. Hill was a native of England, where he was born in Newton, Wales, on May 3, 1840. He came to

the United States at the age of 21, locating at first in St. Louis, where he remained during the Civil War, working on government boats in the river. In 1866 he removed to Quincy and entered the employ of the Smith-Robertson Company. Here he rapidly advanced to an interest in the concern, which became known as the Smith-Hill Elevator Company. As Mr. Hill had made a number of improvements on elevators and held patent rights, the company dropped all machine work and devoted itself entirely to the manufacture of elevators.

When the Otis Elevator Company absorbed the Smith-Hill company, Mr. Hill went to Chicago, but remained only two years. He became interested during that time in an engine and formed the Quincy Engine Company, acting as president of the concern. At the same time the Ellington Manufacturing Company and the Electric Wheel Company were formed and Mr. Hill was made president of the former and vice-president of the latter.

RODNEY C. PENNEY

Rodney C. Penney was born in East Addington, Me., on November 11, 1853, and was educated in the schools and the Eastern Maine Conference Seminary of Bucksport, Me. His first shop experience was with his father at St. Johns, N. B., and his apprenticeship was served in the shop of the Bangor and Piscataquis R. R. of Oldtown, Me., also under his father who was master mechanic of the railroad. He served for a short time as locomotive engineer on the Bangor & Katahdin Iron Works of Brownsville, Me., and in 1885 became general manager of the Mouson, Me., Slate Company. Twelve years later he came to Bangor as general manager of the Hinckley Engineering Iron Works, and during this time was instrumental in consolidating his firm with the Bangor Foundry & Machine Company, under its present name of the Union Iron Works.

With several others he then formed the Penobscot Machinery Company of which he became president and manager. At the time of his death he was acting as Eastern representative and mechanical engineer of the Dodge Manufacturing Company.

Mr. Penney served for a short time in the Senate of the Maine Legislature.

M. W. SEWALL

M. W. Sewall, who died at his home in New York on May 27, 1914, was born in Brownville, Me., on August 2, 1852, and received his technical education in the Maine State College of Agriculture and the Mechanic Arts, graduating in 1875 with honors. In the following year he entered the employ of the Baldwin Locomotive Works in Philadelphia. In 1878 he became head draftsman for the Edge Moor Iron Company, and had subsequent experience as draftsman and superintendent of erection on machine and boiler shop tools, for Hilles & Jones of Wilmington, Del., and in designing, erecting and fitting up the new shops of the Yale & Towne Manufacturing Company. In 1884 he became assistant engineer of the Pneumatic Dynamite Gun Company of New York, where he had charge of the erection of guns on board the U. S. S. Vesuvius. He was also for a short time with the Cable Road of New York, where he had charge of designs of winding machinery.

At the time of his death he had been in the employ of the Babcock & Wilcox Company, New York, for 22 years, having had general supervision of the drafting room for the earlier part of this period, and devoting his time of late to experimental work on chain grate stokers, furnace design, and improvements in boiler settings. He had made a number of inventions in this field.

Mr. Sewall was esteemed by all who knew him for his conscientious spirit, upright character and gentleness. He was unselfish in imparting the results of his experiments to others and was ever ready to lend a helping hand to those about him.

POWER DEVELOPMENT AT THE HIGH DAM BETWEEN MINNEAPOLIS AND ST. PAUL

BY ADOLPH F. MEYER,[1] ST. PAUL, MINN.

Non-Member

The project for the improvement of the Mississippi River between Minneapolis and St. Paul had its inception in 1866. No definite action was taken, however, until 1894, when plans were developed for two locks and dams of about 13-ft. lift each, one at the site of the present High Dam, and another about three miles above the High Dam, near the Selby Avenue Bridge.

Work was commenced on the upper dam, known as dam No. 2. After about $750,000 had been spent, in the days when dry concrete was the order of the day and Portland cement was a luxury that could be advantageously diluted with ground sand, the proposition of utilizing the fall in the Mississippi River in this vicinity for power development received the attention of a special board of U. S. Army engineers, in 1907. This board reported that no power could be economically developed at the proposed 13-ft. dam No. 1, at the site of the present High Dam; that a small plant might be installed at dam No. 2; but that the probable saving estimated at $2000 per annum which would result from a 1300-h.p. development would not warrant the carrying out of the project.

This board predicted, however, that before many years had elapsed it would be economically desirable to build a high dam in the vicinity of the proposed Low Dam No. 1, which is the site of the present High Dam, where a head of probably 35 ft. might be secured, and a total of 15,000 to 20,000 h.p. developed.

The matter of power development was temporarily dropped until 1910 when a report was made by a second board of U. S. Army engineers favorable to the construction of the High Dam. The sentiment of the board as well as of the community was in favor of co-operation with the cities of Minneapolis and St. Paul and both cities passed resolutions pledging themselves to pay the additional cost of raising the projected navigation dam to a height of approximately thirty feet to permit the development of water power.

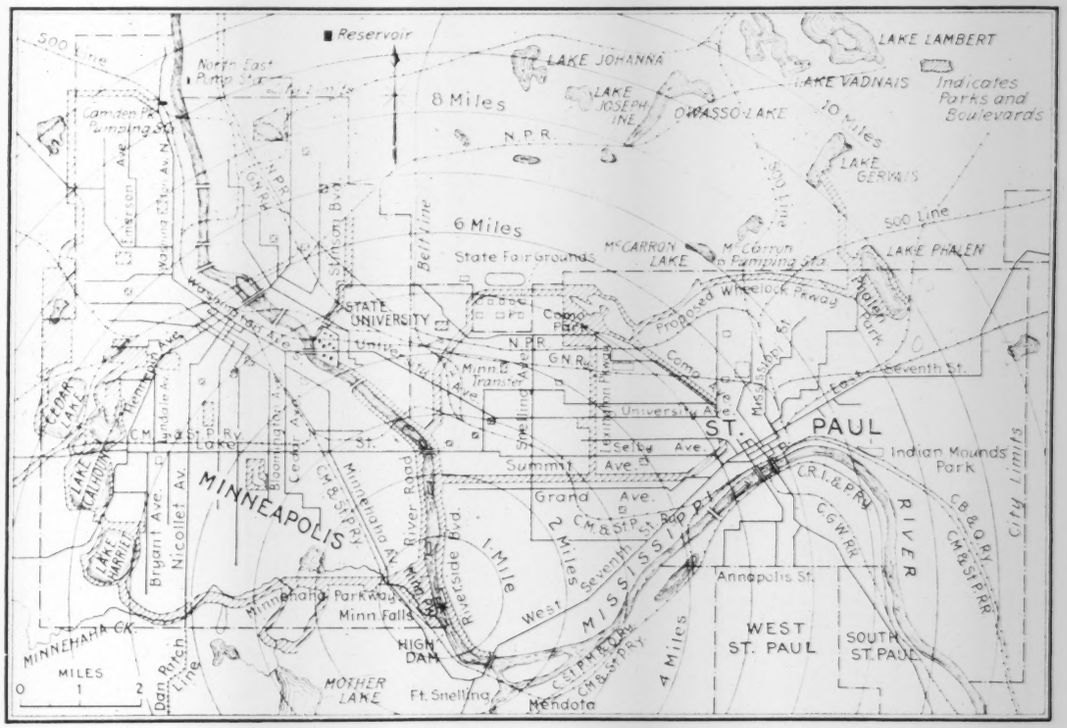

FIG. 1 MAP OF MINNEAPOLIS AND ST. PAUL SHOWING LOCATION OF THE HIGH DAM

The Board of Engineers for Rivers and Harbors concurred in the recommendations of the Special Board and the Chief of Engineers recommended that negotiations be entered into whereby the municipalities

[1] Consulting Engineer, 1000 Germania Life Bldg.

Presented at the Spring Meeting, at St. Paul-Minneapolis, 1914, of The American Society of Mechanical Engineers.

of Minneapolis and St. Paul would become the lessees of any surplus power that might be created.

In the River and Harbor Act of 1910 Congress adopted the modified project as recommended by the Chief of Engineers, with the provision "That in the making of leases for water power a reasonable compensation shall be secured to the United States, and the rates as fixed shall be subject to revision by Congress."

At the following session of the Legislature of Minnesota a bill was passed permitting the formation of public corporations for the purpose of developing water power. Under this act there was immediately incorporated the Municipal Electric Company, composed of the State University and the cities of Minneapolis and St. Paul.

Fig. 2 Site of Dam No. 1, Known as High Dam, Across the Mississippi, Between Minneapolis and St. Paul

In 1913 a bill was introduced in Congress by Hon. F. C. Stevens, providing for a coöperative agreement with the cities of Minneapolis and St. Paul and the State University, whereby, if it becomes a law, the Municipal Electric Company may lease the available water power upon the condition, among other things, that this company pay not less than 3 per cent interest on the amount which the government will have expended for the purpose of making the water power available.

AVAILABLE POWER

The amount of water power which will become available through the construction of the High Dam can be ascertained with considerable accuracy, inasmuch as good physical data are available.

Estimates of stream flow have been made by the St. Anthony Falls Water Power Company and the Minneapolis Mill Company at their plants in Minneapolis, covering a period of more than 20 years. In the more detailed analysis of available power which was made, however, the records kept by the U. S. Engineer office at St. Paul, during the eight years from 1905 to 1912 inclusive, have been used.

The diagram in Fig. 9 shows graphically the elevation of "tail water" and "head water" at the various rates of discharge. The head water curve gives elevations one foot below the maximum permissible elevation as computed, to which the water above the dam can be raised without producing backwater at the lower power dam in Minneapolis. The present dam is being constructed with its crest at an elevation of 743.5 Cairo datum. The tail water curve gives the mean elevation of the water surface for various rates of discharge, based on the readings of the government gage at the site of the dam during the past eight years, taking into account the lowering of the tail water which will result from dredging a 6-ft. channel below the lock, the backwater from the Minnesota River at flood stages, and backwater from ice conditions in the winter.

The head curve gives the mean head which would be available on the assumption of three feet of flashboards on the dam at low water, and a turbine installation capable of using about 5000 cu. ft. per second. It will be noticed that the head varies from a maximum of 36½ ft. at low water to a minimum of 22 ft. during extreme flood conditions, such as might occur for a few days perhaps once in ten years. The normal head may be assumed as 34 ft. For perhaps twenty days a year on an average, or 5½ per cent of the time, the available head will be reduced during high water to less than 29 ft.

Water Available. Table 1 gives the mean monthly stream flow at the dam site for the years 1905 to 1912 inclusive. It will be noticed that the mean monthly

TABLE 1 MEAN MONTHLY DISCHARGE
1905–1913

	1905 c.f.s.	1906 c.f.s.	1907 c.f.s.	1908 c.f.s.	1909 c.f.s.	1910 c.f.s.	1911 c.f.s.	1912 c.f.s.	1913 c.f.s.
Jan.	3174	6667	6220	2390	3350	4198	1764	1840	2600
Feb.	2745	6280	6250	2750	3300	4011	1799	1750	2200
Mar.	5241	7320	11600	4550	4300	9470	2338	2140	2880
Apr.	9775	24653	25099	8185	11721	8640	3404	7080	5125
May	21013	20227	13673	13300	11910	6280	4688	16080	7850
June	23749	29090	18681	32079	11950	4330	4762	7240	6015
July	31762	16525	8266	14364	6160	*3500	3719	5280	8950
Aug.	15700	9185	7347	6992	8570	*3400	3400	5100	6255
Sept.	12874	10965	7149	5100	6480	*3800	3588	5020	5990
Oct.	11067	11378	7674	5980	5420	3210	4351	4840	.....
Nov.	9743	11301	7745	5070	5350	2690	2712	3840	.....
Dec.	8163	6980	3310	3800	5120	2010	2355	2890	.....
Mean Annual	12920	13390	10250	8710	6965	4630	3240	5260	.....

* Modified on basis of Anoka discharge.

flow is below 2000 cu. ft. per second for four months in eight years. The minimum mean monthly flow is 1750 cu. ft. per second. In computing the minimum amount of power which would become available at the dam, an extreme minimum flow of 800 cu. ft. per second has been assumed. Such a flow, however, has in the past occurred for only a portion of a day during

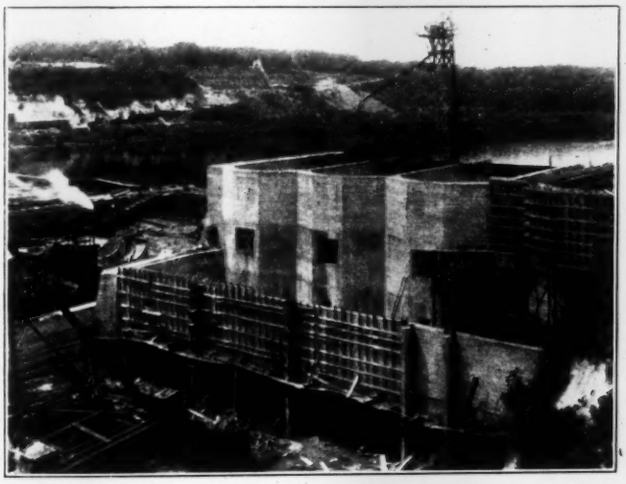

Fig. 3 Construction View of Power House, July 1913

sudden periods of extremely cold weather. On such occasions the normal flow of 1500 to 2000 cu. ft. per second is usually re-established in two or three days. A minimum winter flow has been assumed as follows: 800 cu. ft. per second for one day; 1300 cu. ft. per second for three days; 1500 cu. ft. per second for five days; and 1750 cu. ft. per second for one month.

Effect of Pondage. The area of the pool above the dam at the 740 contour has been determined by planimeter measurements on recent government maps to be 22,500,000 sq. ft. Assuming the pool to be full to the top of the flashboards at the approach of an extremely cold spell, the water surface would be lowered 4.2 ft. in order to augment the supply from 800 cu. ft. per second for one day, and 1300 cu. ft. per second for two additional days, to a mean of 1500 cu. ft. per second. As the available head, in winter, would be at least 36½ ft., the net head which would remain available after drawing down the pool would still be 32.3 ft. By operating the steam pumps to provide the municipal water supply for Minneapolis and St. Paul, or by drawing upon the supply stored in the reservoirs, or both, the station load can be sufficiently reduced to enable the pool to fill again in two or three days.

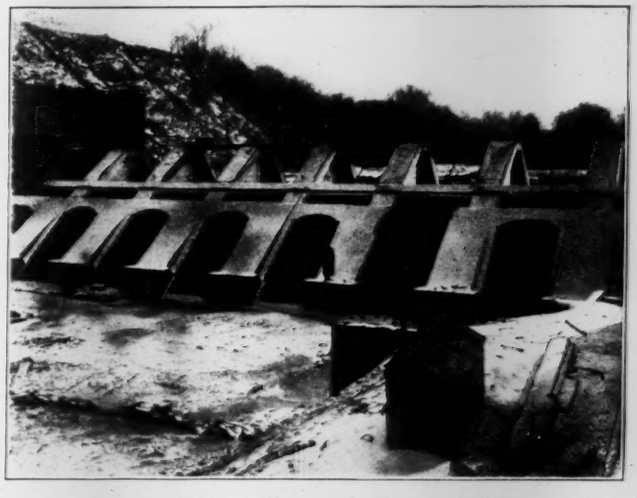

Fig. 4 View of High Dam, January 1914

Power Available. Table 2 gives the number of days per year during which certain amounts of power in blocks of 1000 kw. would have been available for each year from 1905 to 1912 inclusive. A flow of 1750 cu. ft. per second corresponds to about 4000 kw. at the switchboard, assuming an overall efficiency of 75 per cent; 1500 cu. ft. per second under 32.3 ft. head corresponds to about 3100 kw. This is the maximum amount of power which could be counted on with positive certainty 24 hours of the day, and every day in the year.

ECONOMICAL SIZE OF INSTALLATION

The desirability of utilizing, for power development,

TABLE 2 NUMBER OF DAYS PER YEAR CERTAIN AMOUNTS OF POWER WOULD HAVE BEEN AVAILABLE
1905–1912

Year	1000 kw.	2000 kw.	3000 kw.	4000 kw.	5000 kw.	6000 kw.	7000 kw.	8000 kw.	9000 kw.	10000 kw.	10500 kw.
1905	365	365	365	365	365	365	365	365	353	326	297
1906	365	365	365	365	365	365	365	365	365	342	317
1907	365	365	365	362	349	332	322	288	262	261	243
1908	366	366	366	366	366	363	349	303	270	227	180
1909	365	365	365	365	365	365	357	340	305	266	165
1910	365	365	365	363	290	262	215	133	113	104	91
1911	365	365	365	362	307	244	202	142	90	45	25
1912	366	366	366	363	329	273	256	241	228	203	140
Total	2922	2922	2922	2911	2736	2569	2429	2175	2085	1873	1456
Mean	365	365	365	364	342	322	304	272	261	234	182
Per cent	100	100	100	99.8	93.7	88.2	83.4	74.5	71.5	64.3	50
Mean deficiency (days)	....	....	....	1	23	43	61	93	104	131	183

water which is available for only a portion of the year, is dependent mainly upon the relative cost of producing power by steam plants and by water power plants.

If the cost of operating a given steam power plant a certain number of hours a day for the portion of the year during which additional water is available is greater than the fixed charge would be on the additional water power installation, plus the cost of operating this additional installation for that portion of the year, it would pay to develop such power.

The curves in Fig. 10 are based on the following assumptions: The Federal Government will have invested

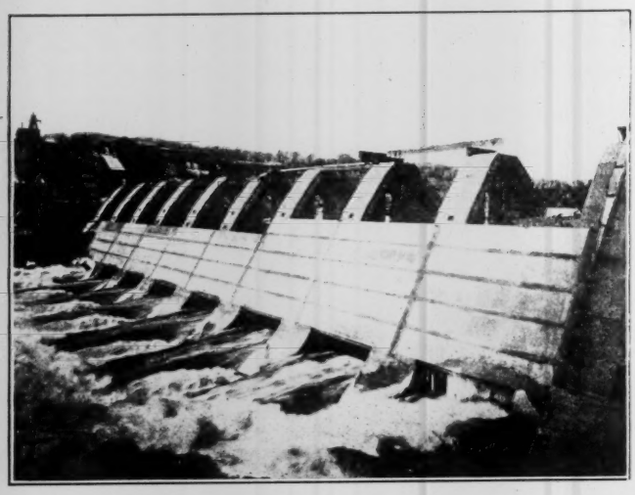

Fig. 5 View of High Dam, March 1914

about $800,000 in a modification of the navigation project, to provide for the utilization of water power, consequently the fixed charges on this amount must be borne by whichever size of installation is adopted. It will at once be apparent that the larger the installation, the less the fixed charge per horsepower will be. This, of course, is true only within reasonable limits, as the draft tubes have already been built, and hence the friction and other losses resulting from the discharge of larger quantities of water by a larger turbine installation will lower the efficiency of the plant.

A detailed estimate of the total cost of an installation necessary to develop about 15,200 h.p. is made later in this paper. The government investment amounts to $52.50 per h.p. and the additional cost of installation will amount to about $41.50 per h.p., or $60 per kw.

The estimated fixed charge for each additional kilowatt of capacity of water power installation is made up of the following items:

4½ per cent interest on $60.00	$2.70
Sinking fund	0.40
Depreciation (or renewal fund)	3.00
Annual fixed charge	$6.10

The cost of operation for the additional water power installation is estimated at $3 per kw. per year. The cost of operation for the steam plant is on the basis of large modern units. Plants of 25,000 to 50,000-kw. capacity, using large units and operating on a 50 per cent load factor, can produce electrical energy at an operating cost of about 0.45 cent per kw-hr. This is equivalent to a total cost of about $28 per kw. per year for 12-hour power.

It would appear from the curves in Fig. 10 that the cost of furnishing 8-hour power by a large steam plant would be the same as the cost of furnishing such power by a hydroelectric plant, using water available 58 per cent of the time. The cost of 12-hour steam power would just equal the cost of hydroelectric power produced from water available 37 per cent of the time. As the ordinary commercial light and power loads have a load factor averaging between 35 and 50 per cent, it would appear desirable to install a plant capable of using all the water which would, on an average, be available for at least 40 per cent of the time, provided the owner of the water power possessed a large steam plant.

If the Municipal Electric Company undertook to

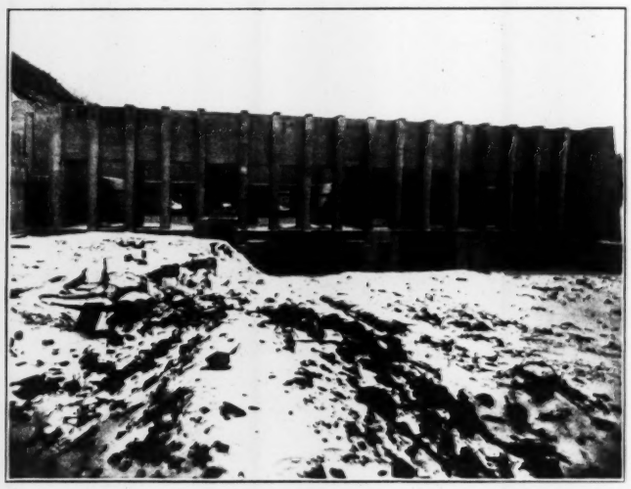

Fig. 6 View of Forebay, February 1914

develop this power, however, it would either have to sell, in the open market, any surplus power not required for public purposes, developed from water available for only a portion of the year, or else install a steam auxiliary. If it sold the excess power in the open market to consumers who were developing their own power by a large steam plant, it could not expect to receive more than about 75 per cent of what this power might be worth to said consumers.

On this basis, power developed from water available 50 per cent of the time might just find a market with consumers who were developing 12-hour steam power. When available at all, such excess power could be furnished at any time of the day, and for 24 hours if necessary, but it would have to be either utilized or wasted, as the water could not be stored. Ample notice, however, could be given consumers.

On the above assumptions, it would appear advisable to install a plant of 10,500-kw. capacity, inasmuch as this amount of power would be available for at least 50 per cent of the time, according to Table 2, smaller amounts being available, of course, for longer periods.

In case the company installed a steam auxiliary plant to supply power on days when the necessary water was not available, so that the power from the combined source could be furnished any hour of the day and every day of the year, the fixed charge would have to be paid on the combined installation, and the total cost of furnishing such power would again depend upon the per cent of time the water was available.

It is assumed that the steam auxiliary power plant would have a capacity of about 5000 kw. and would cost $90 per kw. The fixed charge is assumed as 9.8 per cent, or $8.80 per kw. per year, composed of the following items:

Interest	4.5 per cent
Sinking fund	0.5 per cent
Depreciation (or renewal fund)	4.8 per cent
Total fixed charge	9.8 per cent

The fixed charge on the additional water power installation is assumed as $6.10 per kw. per year, in accordance with the detail estimate previously given.

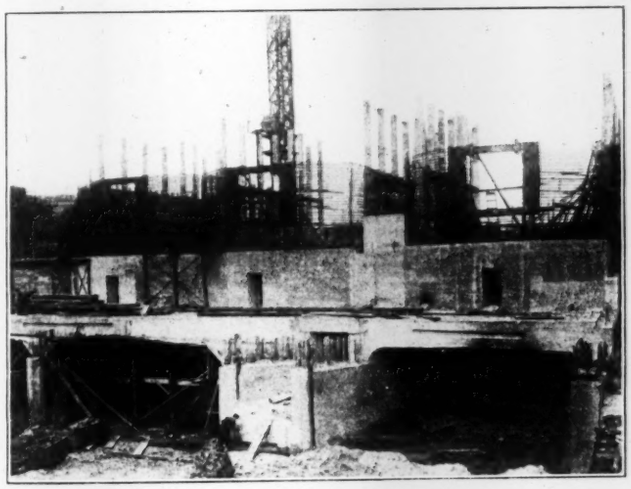

Fig. 7 Construction View, February 1913, Showing Tail Race

Power from such a combined source would have to compete with power produced by large steam plants, if not utilized by the Municipal Electric Company itself. It would appear from the curves, Fig. 11, that water would need to be available 84 per cent of the time in order to bring the cost of combined power down to the cost of 8-hour steam power produced by large plants. For water available 75 per cent of the time, the cost of combined power would just equal the cost of 12-hour steam power, and for water available 70 per cent of the time, the cost would just equal 16-hour steam power. The cost of 24-hour power developed by such a combined plant using water available less than 64 per cent of the time, would be greater than the cost of 24-hour power developed by a large steam plant.

Considering the cost of connecting up, by pole line or conduit, to some large plant, and of the difference between cost and market price of power, it is probable that the Municipal Electric Company could not purchase even large blocks of peak power at less than 0.9 cents per kw-hr. for 12-hour power. On this basis it would just pay to install turbines capable of developing water power which would be available at least 50 per cent of the time, and to add a 5000-kw. steam auxiliary plant when the Municipal Electric Company's own demands for power warranted such installation.

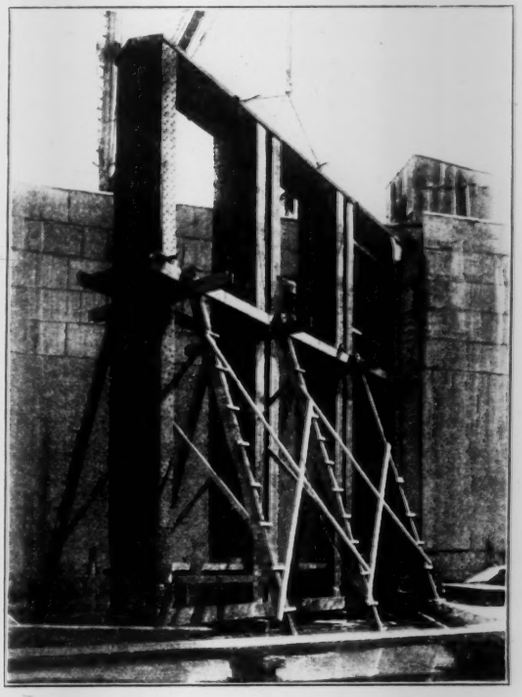

Fig. 8 Lock and Gate, April 1913

INSTALLATION PROPOSED

The great reduction in head during high water makes it necessary to install a plant of very much greater turbine capacity than would be necessary under more uniform head conditions. At times of high water there is not only a reduction in the available head, but also a reduction in the amount of water which any given turbine installation is capable of utilizing. As the discharge from turbines varies with the square root of the head, any given turbine installation at the High Dam operated at a certain gate opening will be able to discharge only about eight-tenths as much water under flood conditions as under low water conditions.

On the basis of Holyoke test data, a preliminary study was made of the probable performance of turbines of the size which it will be necessary to install in order to develop the contemplated power, operating

under the conditions which will obtain at the High Dam, i.e., under a head varying from 36.5 ft. at low water to 22 ft. at extreme flood stage. After this preliminary study had been made, it appeared desirable tentatively to recommend the installation of four units having a rated capacity at full gate under low water head of about 5000 h.p. per unit; either one or two runners to be used on each shaft and the turbines to be direct-connected to 3500-kva. generators. Even this installation, however, would be capable of developing only about 7000 kw. at extreme high water. Very good efficiencies would be secured under heads ranging from

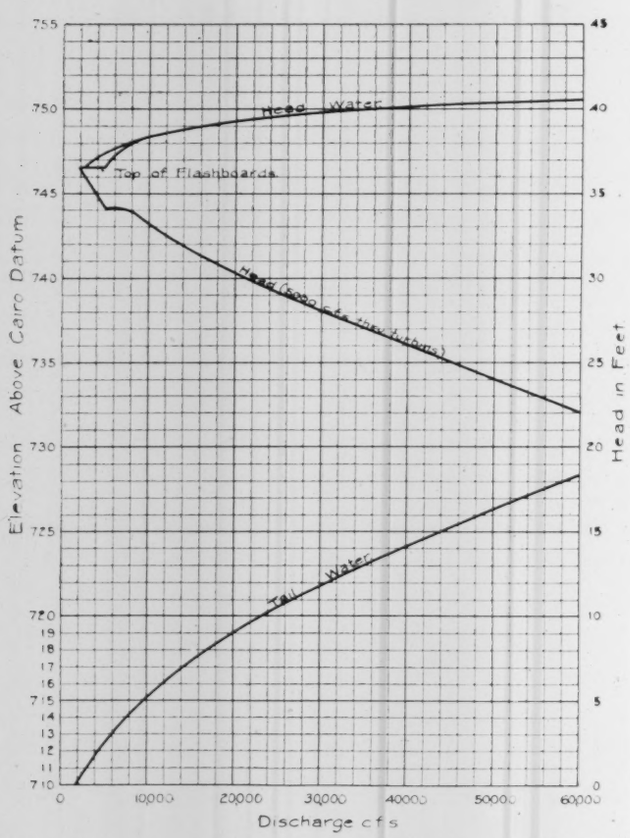

FIG. 9 ELEVATION OF TAIL WATER AND HEAD WATER AT VARIOUS RATES OF DISCHARGE

32 to 36½ ft. when operating such turbines at from 65 to 90 per cent gate opening. Four units would carry the normal station load of 10,500 kw. when operating at about 72 per cent gate opening and under a 34-ft. head. Such an installation would also be capable of developing 10,500 kw. during ordinary flood conditions, under a 29-ft. head, when all four units were operated at approximately full gate opening. Three units at full gate opening under low-water head, with only a small overload on the generators, depending on the power factor, would also be capable of developing 10,500 kw.

It is believed that the rather large installations would be fully warranted by the conditions under which this plant would be required to operate. While the full rated capacity of the plant at low water and under full gate might be considered as 20,000 h.p., the normal capacity would really be only about 15,200 h.p., inasmuch as it would be poor policy not to have a reserve unit under ordinary conditions of head, stream flow, and load.

PROBABLE COST OF DEVELOPING THE WATER POWER

The Federal Government has practically completed the modified project in accordance with the Act of Congress of 1910, and the United States Engineer Office at St. Paul has estimated that the total cost of the project, as modified for the development of water power, including the construction of the power house substructure, draft tubes, etc., will be $800,000 more than the cost of the original project would have been.

In the Stevens bill now pending in Congress, it is provided that the Municipal Electric Company pay not

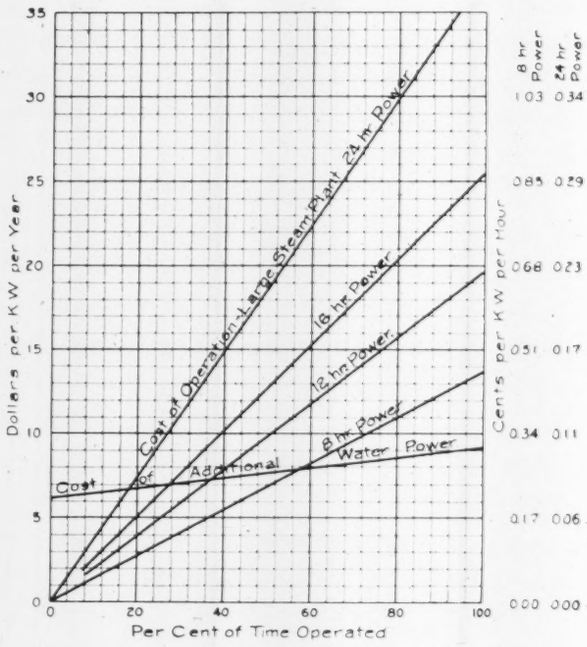

FIG. 10 COST OF OPERATING STEAM, AND FOR ADDITIONAL WATER POWER, FOR DIFFERENT TIME PERIODS

less than 3 per cent interest on the amount which the Government has invested for the purpose of making the water power available. For an installation of 15,200 h.p., the Government investment amounts to about $52.50 per h.p.

Additional Expenditure Required. In order to complete the power house and install the necessary machinery, an additional expenditure of about $630,000 will be required. This includes interest during construction, insurance, engineering, supervision, and contingencies, and $50,000 working capital or "emergency fund," required by the laws of Minnesota under which the Municipal Electric Company is incorporated.

Adding the Government expenditure of $800,000 gives $1,430,000 as the investment cost of the plant.

This amount is equal to about $94 per h.p. at the turbine shaft, and $136 per kw. at the switchboard.

Fixed Charges and Operating Expenses. The fixed charges on the water power plant will be about as follows:

3 per cent interest on $800,000, per annum	$24,000
4½ per cent interest on $630,000, per annum	28,400
Sinking fund to pay off $630,000 in 50 years at 4 per cent	4,050
Renewal of plant in 15 years at 4 per cent	31,460
Maintenance	10,090
Total fixed charges	$98,000

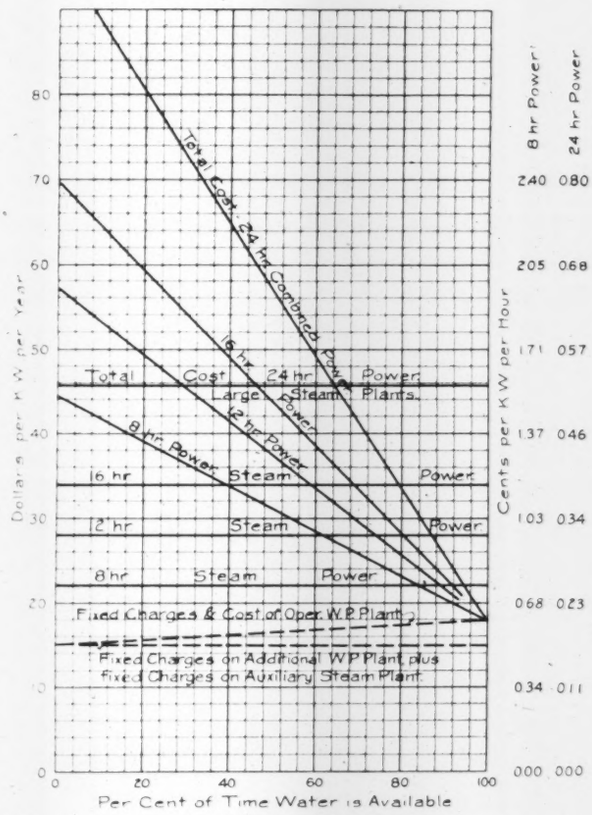

Fig. 11 Cost of Combined Power for Different Periods

Adding to the fixed charges the annual cost of operation and administration, including an allowance for the annual charge on the investment in transmission lines and substations not herein itemized, brings the total cost of developing power to about $150,000 to $175,000 per annum.

Cost of Power per Kw-Hr. According to Table 2, the mean annual deficiency of power up to 6000 kw. is 1,608,000 kw-hr. Assuming that the steam pumps would be operated to supply this deficiency, all power up to 6000 kw. may be considered as primary power as far as the Municipal Electric Company is concerned. The mean annual amount of such power which would have been available during the past 8 years is, on the basis of Table 2, 50,800,000 kw-hr. The total amount of power between 6000 kw. and 10,500 kw., which would have been available during the same time, is 27,900,000 kw-hr., or a total of 78,700,000 kw-hr. of available power per annum. This is equivalent to a mean of 9000 kw., and on this basis the cost of developing 24-hour power would be a trifle less than two tenths of a cent per kw-hr.

If we assume that the power which could not be furnished at all times—the "excess power"—is worth, on an average, one-third as much as the "primary power," there would be an average of 60,100,000 kw-hr. of power available each year. This would make the cost of developing power about a quarter of a cent per kw-hr. If a 5000-kw. steam auxiliary plant were installed so as to make 10,500 kw. available at all times, the cost of developing this power would be about 0.35 of a cent per kw-hr. on the basis of 24-hour power.

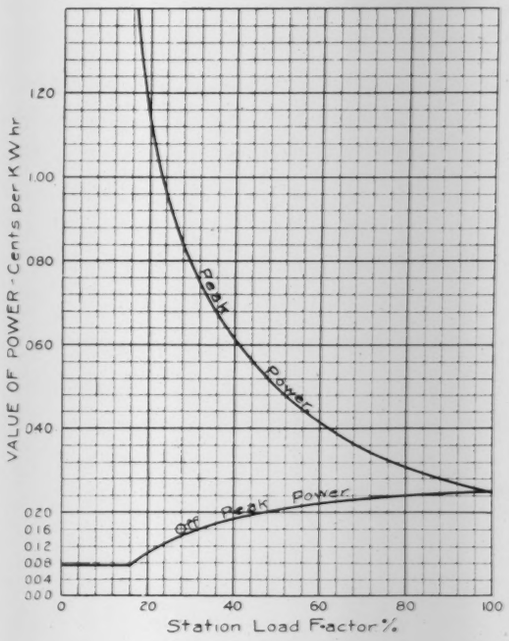

Fig. 12 Relative Values of Peak and Off-Peak Power for Different Load Factors

Fig. 12 shows the relative values, at the station, of "peak" and "off-peak" power for different load factors, on the basis of a cost of a quarter of a cent per kw-hr. for continuous power. If the load factor of the station for any given load were very small, as, for example, in the neighborhood of 20 per cent, off-peak power could be sold at the mere additional cost of operating the water power plant. This would be, in the case under consideration, less than one-tenth of a cent per kw-hr. As the load factor became larger, the value of off-peak power would approach that of peak power, equaling it when the load factor became 100 per cent, and at all times possessing a value about inversely proportionate to its effect in increasing the load factor. The peak power, in order to yield a return

equivalent to a quarter of a cent per kw-hr. for continuous power, would be worth about one and one-fourth cents per kw-hr. at 20 per cent load factor, taking into consideration the slightly lower cost of operation in the case of power furnished for only a small portion of the day, but without taking into consideration the compensating effect of pondage, i.e., assuming that the available water must be either utilized or wasted.

With a station load factor of 60 per cent, under the same assumptions, the value of peak power at the station would be about four-tenths of a cent per kw-hr., and off-peak power would be worth just about half this amount.

When the effect of pondage is taken into consideration, however, the load factor is found to affect the cost of power considerably less than the value of that factor would make it appear. In Fig. 14 is shown a characteristic combined street lighting and miscellaneous light and power load, having a load factor of 40 per cent. Fig. 13 shows a mass curve of actual consumption of current and of mean consumption, or equivalent in supply of water, from which can be scaled the quantity of power which must be furnished by stored water for various mean rates of stream flow. From this value, the area of the pond, and a mean head for each particular condition, the pool fluctuation for various rates of discharge, as shown in Fig. 14, was determined.

The only effect of the load factor, then, in this case where the entire flow of the stream was being utilized through pondage, would be due to a reduction in available head from drawing down the pool, and from a rise in the tailwater at the time of high discharge, i.e., peak load. Instead of the 40 per cent load factor having increased the cost of power 2½ times, as indicated in Fig. 12, it has, in reality, increased the cost, under the conditions assumed, less than 10 per cent. Not until the amount of water continually available has increased to 4500 cu. ft. per sec., or peak load conditions, will the value of power be increased 2½ fold by a 40 per cent load factor.

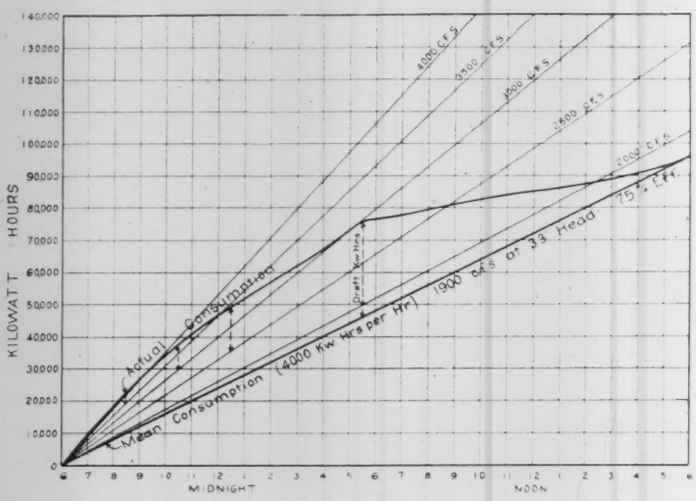

Fig. 13 Mass Curve of Consumption

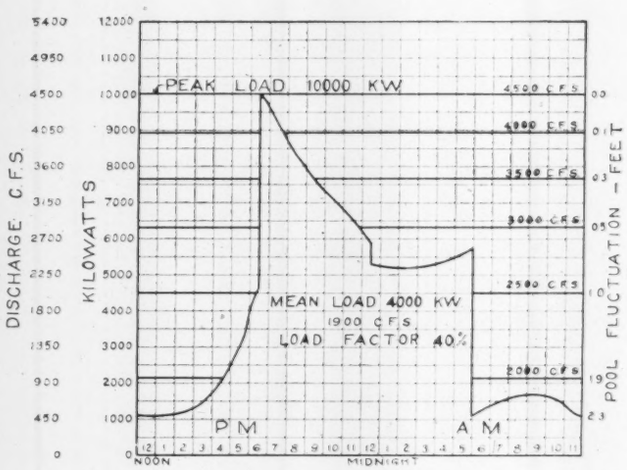

Fig. 14 Typical Load Curve

UTILIZATION OF POWER

Present Consumption. Statistics were obtained, from all available sources, giving the amount of power at present consumed by the Federal Government, the State of Minnesota, and the cities of Minneapolis and St. Paul, for what might be called public purposes. These quantities are graphically shown by months in Fig. 15.

It is apparent that the city of Minneapolis is using more power than the Federal Government, the State of Minnesota, and the city of St. Paul together. The principal reason for this is that the city of Minneapolis has recently installed motor-driven pumps for pumping its water supply. The power used by the two city halls, the street lights, the Minneapolis pumps, and the power which would be used in St. Paul for pumping, if a motor-driven pump were installed at the McCarron Lake pumping station, are also shown individually.

Station Load. Inasmuch as there is considerable loss in the transformation and distribution of electrical energy between the station and the place of consumption, the amounts consumed were reduced to their various equivalent station loads on the following basis: It was assumed that of 100 h.p. available at the station switchboard, 87.5 h.p. would be available for the pump motors, and 75 h.p. for the street lights, and for most of the miscellaneous light and power uses. The latter is equivalent to an overall efficiency of conversion from hydraulic power to electric current at point of consumption of 56 per cent, and is well on the side of safety.

Future Consumption. In estimating the probable consumption in 1920, the amounts used at present in the public buildings have been increased by 25 per cent. The present gas and gasolene street lamps in the cities of Minneapolis and St. Paul have been assumed to be replaced by electric lights in the proportion of about one arc light, or equivalent, to four existing gas or gasolene lamps. A lighting installation of 4000 arc lights and 1000 ornamental lights or equivalent, was assumed for Minneapolis, and 2700 arc lights and 600 ornamental lights, or equivalent, for St. Paul. This would practically double the present consumption of electric current for street lighting purposes in the two cities.

The future power requirements for pumping represent what will be needed in 1920, on the basis of the past few years' increase in water consumption. It represents an increase of practically 50 per cent. The future requirements of the State University are based on an approximate doubling of the present consumption.

Load Factors. The mean annual station load from the above estimated consumption of current for public purposes will be about 5500 kw. by 1920. The peak load will be about 8500 kw. and the load factor about 65 per cent. In Figs. 16 and 17 are graphically shown typical December and June station loads, planned with a view to keeping the station load factor as large as possible. By running the Minneapolis and St. Paul pumps during the off-peak hours, a December load factor, for present loads, of about 87 per cent can be secured, and for future loads, a factor of about 74 per cent can be secured. The load factor for the miscellaneous light and power load is about 44 per cent in December, and 60 per cent in June. That for the street lighting load is about 56 per cent in December and 27 per cent in June. These load factors on the whole are considerably better than those usually obtained from commercial light and power loads. During June, the present station load factor would be about 76 per cent, but the future load factor would be reduced to about 60 per cent unless the installation of motor-driven pumps in Minneapolis is increased. The present installation will soon be insufficient to supply the increased water consumption even if run 24 hours of the day. This, of course, is uneconomical, as it would result in adding the Minneapolis pump load to the peak. Before this condition is reached, however, Minneapolis no doubt will find it advisable to install an additional motor-driven pump; in fact, this is already under consideration.

The mean 1920 December station load will be about 6000 kw. This would be secured from a discharge of 2600 cu. ft. per second under the low water head. The mean 1920 June station load will be about 5200 kw.

The total amount of electrical energy which will probably be required in December 1920, for street lighting and for miscellaneous light and power purposes, measured at the station, is about 93,000 kw-hr. This amount of electrical energy would be secured from a discharge of 1650 cu. ft. per second under the low water head.

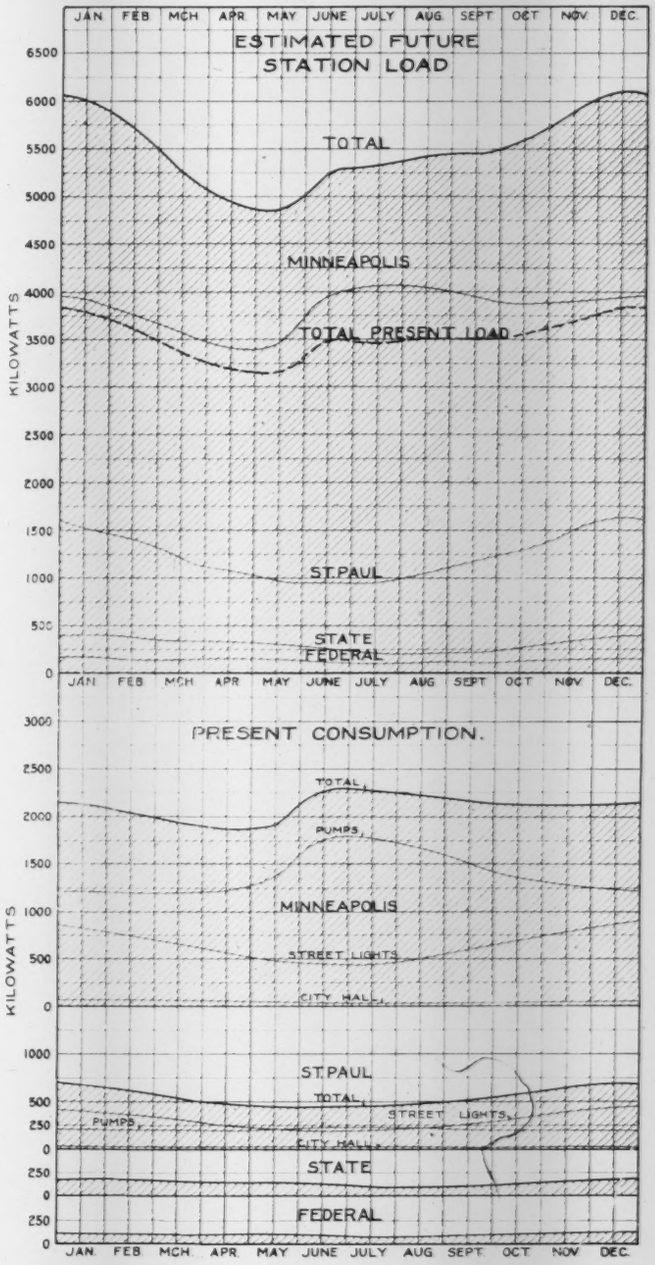

FIG. 15 PRESENT AND ESTIMATED FUTURE CONSUMPTION OF POWER IN THE VICINITY OF HIGH DAM

Use of Steam Pumps. Through proper coöperation between the cities, the State University, and the Municipal Electric Company, the existing steam pumping plants of the two cities can be made to serve economically the dual purpose of emergency pumping equipment and small auxiliary power plant. So far as the

reliability of a water supply is concerned, a combined steam and electric pumping plant is preferable to a plant dependent upon electrical power alone. So far as additional power required during periods of low water is concerned, the steam pumping plants constitute the very best small auxiliary. They can deliver water to the reservoirs at less operating cost than a 5000-h.p. steam plant, generating current which has to be transmitted and transformed, and then applied through a motor to centrifugal pumps, can possibly do. As the steam pumping plants are in existence, they serve as emergency pumping equipment and auxiliary power plant of about 2500 kw. capacity at the same time.

The reservoir storage at the Minneapolis filtration plant amounts to about 80,000,000 gal. By 1920 the daily water consumption in winter is not likely to exceed 40,000,000 gal. The Minneapolis steam pumps have a capacity of 30,000,000 gal. daily, so that in case the electrical pumps were temporarily disabled, or no current were available, the steam pumps, by running continually, would be able to furnish the additional water necessary to supply the city for 8 days. The St. Paul steam pumps have an aggregate capacity of

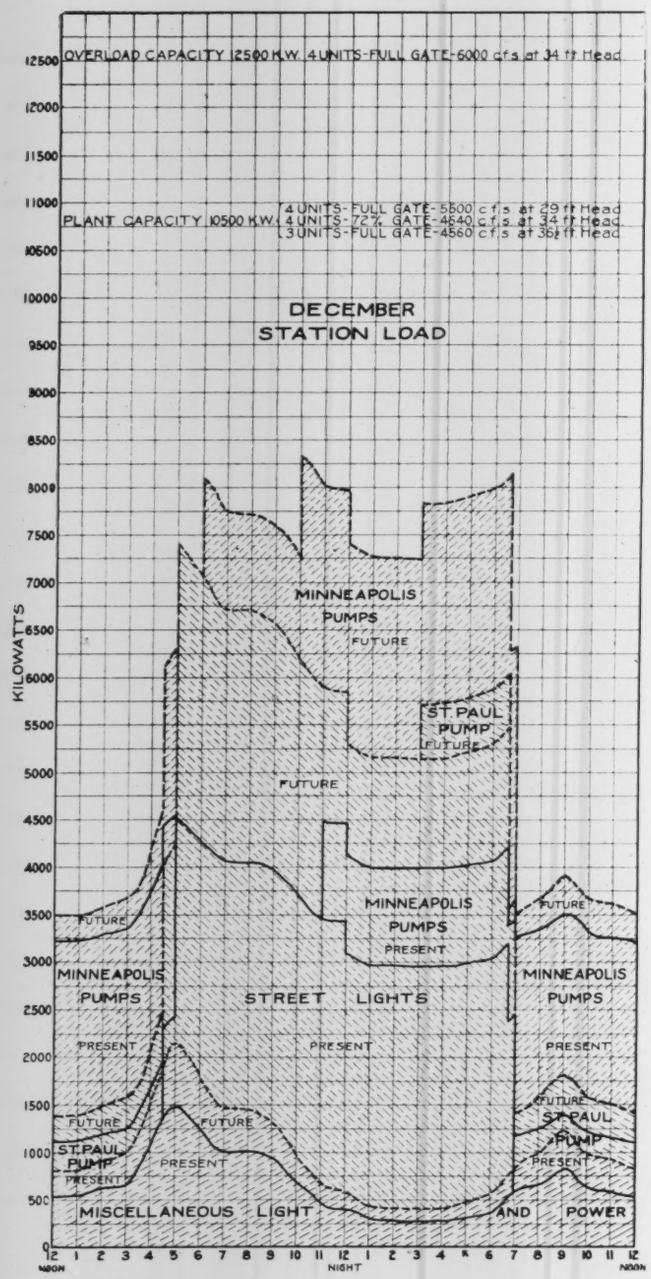

Fig. 16 Typical December Station Load for Public Purposes

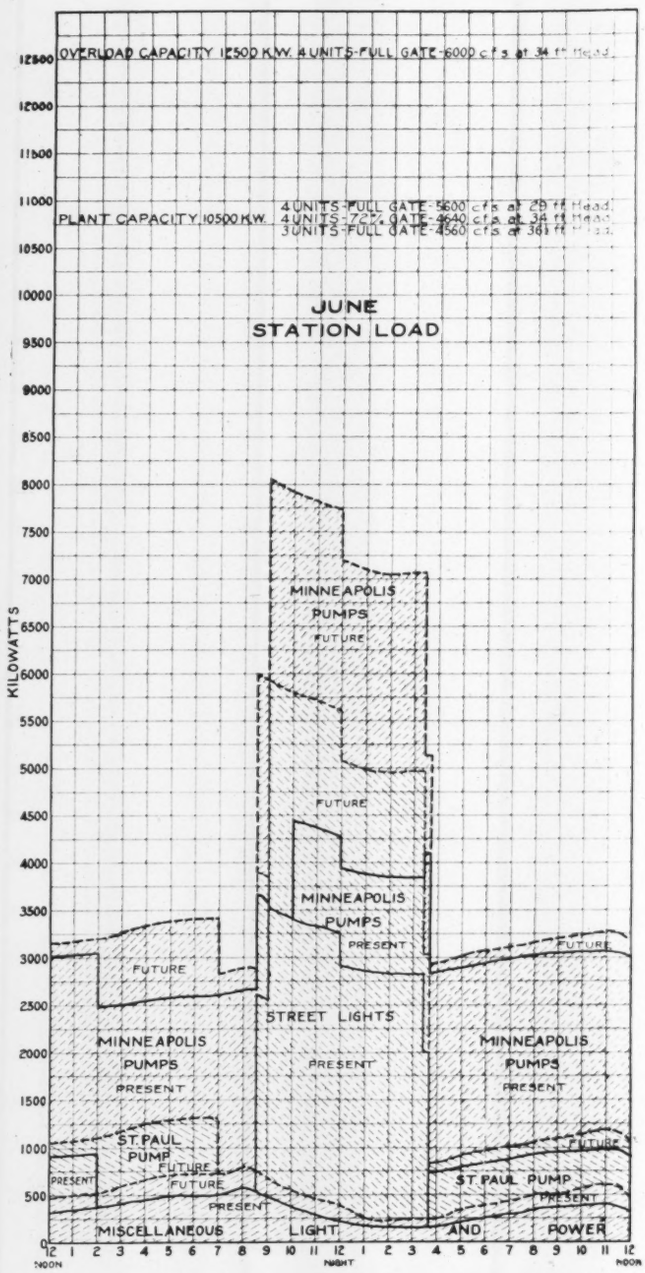

Fig. 17 Typical June Station Load for Public Purposes

about twice the present mean daily water consumption. A flow of 1750 cu. ft. per second is equivalent to about 98,000 kilowatt hours of power per day. Whenever, because of low water, the power output fell to this amount, it would be necessary to run the two Minneapolis steam pumps practically all day. Whenever the discharge fell to 2000 cu. ft. per second, it would be necessary to run these two Minneapolis pumps about 16 hours a day. It is probable that it would be necessary to run the steam pumps for at least a portion of the day, on an average 25 to 30 days a year, or 5 per cent to 8 per cent of the time. This is not entirely a disadvantage, however, as it would serve to insure the emergency steam pumping equipment of both cities being kept in good operating condition.

On the basis of statistics obtained from the 1912 report of the Supervisor of Water Works, Minneapolis, the fuel and labor cost of operating the steam pumps has been computed to be equivalent to a rate of practically one-half a cent per kw-hr. for the electric pumps. This is about half the cost of electric power developed by a small auxiliary steam plant.

As previously indicated, during extremely cold weather the maximum available 24-hour power may occasionally fall to less than 4000 kw. By utilizing the steam pumping plant for a few days each year, and drawing on the available pondage, the maximum available primary power can be raised from 3100 to about 6000 kw., and at a lower cost than could be done by a small steam power plant.

Even if, in the near future, there should be an extreme flood, such as may occur for a day or two once in 15 or 20 years, the water power plant would still be able to carry a peak of about 7000 kw. This is more than would be required for the street lights and miscellaneous light and power uses. The steam pumps could again be run for a few days to supply any deficiency.

Surplus Power. It is estimated that by 1920 the mean annual rate of consumption of power for the purposes previously outlined will be about 4520 kw., if the gas and gasolene lights are replaced by electric lights as contemplated in this paper. This is equivalent to a mean annual station load of 5500 kw. The mean December station load would be about 6000 kw., but in order to be able to meet the Municipal Electric Company's own peak load at times of high water, a very much larger installation would be required. In fact, an installation rated at 10,500 kw. under normal head and with one spare unit would furnish only very little more than the peak load which will probably have to be carried during the spring months by 1920.

Assuming, then, that the Municipal Electric Company in the near future would want to reserve for its own uses, as previously outlined, 6000 kw., there would still remain about 4500 kw. of excess power. The mean annual amount of available power will be about 9000 kw. With an installation as contemplated in this paper, it would be possible to carry a peak load for several hours of 12,500 kw. under normal head, and for one hour a peak load of about 13,500 kw. Inasmuch as the Municipal Electric Company's peak would be about 8500 kw. by 1920, it is apparent that 4000 or 5000 kw. of excess power, when available at all, could be carried over the peak. This, undoubtedly, would make the excess power of considerably greater value than if it were necessary to sell it all as off-peak power.

The installation contemplated in this paper would assure a reserve unit for use in case one of the other three units was temporarily disabled. This unit could also be put into service whenever, at times of ordinary high water, such as may occur for about a month each year, the head is reduced to a point where the three units would no longer be able to carry the load. It would also serve to make available, as peak power, the excess power, whenever such power could be furnished at all. Until the demands of the community, for power for public purposes, enable the Municipal Electric Company to utilize all of the available power, the surplus should be disposed of in such manner as would be of the greatest benefit to the public.

PROBABLE BENEFITS

The writer has made detailed estimates of the savings to the community that would result from the operation of the proposed hydroelectric plant, and places it conservatively at about $200,000 per annum by a few years after the Municipal Electric Company has begun operations.

DISCUSSION

At the time of the Spring Meeting high water in the Mississippi made it impossible for those in attendance to inspect the construction work of the High Dam. In presenting his paper, therefore, the author showed slides of the dam and power house in various stages of completion, which gave a clear idea of the work in progress. He concluded with comments on the high stage of the river and the amount of power that would be available at different levels, referring to the effect of the Government reservoirs at the headquarters of the river, which comprise the largest reservoir system for stream regulation in the world.

As a result of these remarks most of the discussion which followed centered about the effect of the reservoirs, both in relation to the use of the river for navigation purposes and the development of the power project at the High Dam. This subject is one of great magnitude and since the short time available at the meeting permitted only fragmentary discussion quite inadequate to the problem, no space has been given to a report of the discussion.—EDITOR.

INDUSTRIAL SERVICE WORK IN ENGINEERING SCHOOLS

BY JOSEPH W. ROE, NEW HAVEN, CONN.

Member of the Society

A social force has been at work in our engineering schools for the past few years which materially affects the attitude of students, on leaving college, towards working men. It concerns a steadily growing portion of the membership of The American Society of Mechanical Engineers,—that in the Student Branches. As many of these members will be called on for leadership in this Society in the coming generation, whatever helps or hinders their broadest professional training should have its careful consideration.

In the winter of 1907-1908 some engineering students of the Sheffield Scientific School at Yale started an activity which for want of a better name, has been called industrial service work. It consisted of a study of welfare activities, living and working conditions in American industries, and a definite attempt to render some useful service to workingmen in the city. As a large industrial center, New Haven has many thousands whose greatest need is a knowledge of the English language. It was felt that to help meet this need was the most practical service the students could render. A system of instruction in English was evolved, based on the familiar phases of everyday life, which did not require a knowledge of the foreign language on the part of the teacher. Groups were organized in various parts of the city wherever they could be gathered, the general plan being that the students should go to the men rather than to attempt bringing the men to any school or institutional buildings. The plan worked well from the start. The classes were full and many newly arrived immigrants were reached who would not have come near a public night school.

In connection with this teaching work, which was the main activity, a series of talks on industrial subjects was given to the students by such speakers as John F. Stevens of the Panama Canal, S. B. Thorne of the Buck Run Coal Company, Charles Stelzle, Miss Gertrude Beeks, Prof. Edward A. Steiner, Charles R. Towson, and others. A small library on immigration and industrial conditions was set at work and some of the books became well worn.

The hold which it took on the better type of student, as well as its effect on him, were interesting and significant. The work was wholly voluntary and done in their own free time, yet many gave two or more evenings a week throughout the whole winter to it. The word " mucker " dropped from their vocabulary. The " wop," the " hunkie " and the " dago " became people, acquired names, and sometimes commanded their genuine respect. Student and workmen were coming, often for the first time, into direct and friendly contact and finding out for themselves how the other lived, worked and thought. From the knowledge so gained, there came an attitude of frank good will and friendliness on the part of both.

The following winter a number of other engineering schools undertook a similar work with similar success. Under the leadership of the industrial and student departments of the Y.M.C.A., it has spread rapidly throughout the country until now, only seven years later, more than 3000 students are engaged in it and are coming into contact with about 50,000 workmen.

In a general way the activities of the student are: (*a*) reading and investigation of the general principles involved; and (*b*) a personal contact with workmen in some line of service. The latter takes many forms, but chiefly that of teaching. In all industrial centers there is a large number of men whose greatest need is English. Without it they cannot get a job alone, buy their own supplies, understand instructions for their work or even for their own personal safety; hence the padrone and labor contractor. With a knowledge of English, an opportunity of becoming industrially independent is opened up to them. Other subjects, of course, are taught, such as first aid to the injured, elementary mathematics, drawing, and civics; but English is the greatest need.

The service is not, however, confined to instruction nor to foreigners. Any sound basis of contact is utilized. Wherever possible, the classes or groups are kept small, not over five or six men to a teacher, in order to insure the element of personal contact. The work is done independently of the college curriculum, on a voluntary basis, and without pay, as this basis is by far the best in its effect on the student. In some cases the faculty has coöperated by taking over that portion of the program relating to speakers and has arranged a course of industrial lectures for all upper classmen. This has been done recently at the Sheffield Scientific School with good success. The advantages of industrial service work are felt by the employer, the workman, the student, and the community.

Employers, some of whom were at first critical, welcome it for its direct benefit and support it by giving access to the workmen, by furnishing places for teaching and in many cases paying the small necessary expenses. They see, too, its effect on the student. An employer recently said: " Two college men of equal training worked in my shop last summer. One of them ' knew it all,' was despised by the men and got

Presented at the Spring Meeting, at St. Paul-Minneapolis, 1914, of The American Society of Mechanical Engineers.

fired. The other became 'one of the men' and learned from them, and nearly every evening some of the working men went to his room and he helped them in mathematics, mechanics, plain reading, etc. That fellow has a big job awaiting for him because he has learned how to handle men to his advantage."

Some of the advantages to the workmen have been pointed out above. He is given nothing which pauperizes him or lowers his self-respect. Usually he is suspicious at first of the student as a representative of the capitalistic class. He finds, however, by a contact which he has in almost no other way, that at least these boys are clean-cut, fair-minded and friendly. Those who are familiar with the attitude of workmen know their latent feeling of contempt for the young college engineer who comes among them, possibly strong in things which they little appreciate, but weak in practical things, where they are strong. We have all seen, however, the loyalty with which old, hard-headed workmen will serve young college men who have *won their confidence* and made good with them. Their distrust gives way to a feeling of pride in their successes such as they might have for their own sons who have been given advantages they themselves have not had. This change in attitude of the workman has been clearly marked, and shows a breaking down of social antagonism—a help to all (see Fig. 1).

The gain to the student, while not obvious, is quite as great. More than half the value of an executive engineer lies in his capacity to understand and work with his men. No amount of technical proficiency can make up for the absence of it. One of the greatest weaknesses of the college-trained engineer is the unconscious attitude of assumed superiority which he sometimes has, for a time at least, after graduation. It seriously limits his usefulness and his capacity for learning. The ability to understand and to work with men is the most valuable asset he can have. This our colleges, as colleges, cannot teach, for it is based on a knowledge of human nature and there is no textbook on human nature. It can be learned only by personal contact; and genuine personal contact is possible only on a basis of mutual respect and friendliness. The students are learning much more than the possibilities and limitations of welfare work. They are acquiring a personal attitude toward fellow workmen which starts them out right.

It is possible to give here only a few expressions of how this work is held by students of the stronger type. One says: "It's a wonderful, and sometimes a humiliating revelation to a fellow to get up against some of these foreign men. It just makes a fellow readjust a good deal of his previous thinking." Another, one of the best known college athletes of the day said a few months after graduation: "Remembering what I learned in this movement at Yale, when I became foreman I treated my gang of Italians as men and not as dogs, and it was really pitiful to see the way they returned the little kindnesses I showed them. Each day I was met with cheery words of greeting. When the job was complete, the men came to me in a bunch, thanked me for the fair way I had treated them and said they would like to work for me always." Another, a football captain, said a short time ago: "This industrial work is the livest thing that's struck college since I've been here. It's a real job and it's practical. Everyone of us who goes into it is bound to acquire an experience in dealing with men which the curriculum cannot give, and we need it."

Last year one graduate, who went into the office of a bituminous coal mine, gathered together a class of seven men to prepare them for examinations as fire bosses and underground foremen (see Fig. 3). With this instruction the men passed the examinations and

Fig. 1 Industrial Service at Work
Teaching English at a Construction Camp. The Lesson is Posted on the Side of the Car. The Breaking Down of Class Feeling is Clearly Present

their potential earning capacity per year was increased an average of $266.40 per man. As a result, this year 40 men applied for similar instruction and as this was beyond his capacity, arrangements were made for paid night instruction in one of the public school buildings which has been carried on by others under his supervision. Without multiplying instances we find results like this wherever men go who have had this industrial service training.

The advantage to the community needs but little emphasis. When one considers the type of Americanism with which the immigrant first comes into contact, it is no wonder that his social standards remain low. The only Americans, whom many a Pole or Italian meets, are the saloon keeper, the ward heeler, and the grafter. Contact with clean-cut, wholesome, educated college boys opens up to him a type of Americanism which he sees in no other way. It raises his standards and kindles his ambition. The men come to the students with all sorts of questions which indicate a hunger for information and improvement.

As the industrial service movement has developed it is quite distinct from ordinary social welfare work. It

has two clearly defined objectives. The first one is immediate benefit to the laborer whom the student may be teaching; the second, less obvious, but main purpose, is the subjective effect upon the student himself, the developing of an attitude of mind, and a knowledge of the social aspects, the responsibilities, and the opportunities of his engineering profession. While the latter should not be over emphasized to the student it is never lost sight of by those directing his activities.

Such briefly is the development and nature of industrial service work. In appraising its value it is well to look at it broadly. The work which these students are doing is part of a general trend, of a changing of social standards; and of a development away from the industrial individualism of a hundred years or even fifty years ago. The probability is that this tendency will increase rather than diminish during the coming generation.

Fig. 2 Another Phase
A Noon-Day Class in a Foundry in First Aid to the Injured
Practically all of these Men are English-Speaking

Industrial history shows nothing more clearly than the fact that while tools of production make high social development and physical welfare possible, they by no means insure them. The series of inventions of Hargreaves, Arkwright, Eli Whitney, Watt, and other great inventors from 1760 to 1800 resulted in a tremendous readjustment of social conditions. In England, where this change was felt first and most severely, tens of thousands of artisans found their handicrafts supplanted. They drifted into the new industrial centers and found work as best they could. The resulting conditions are a matter of history. The industrial leaders had little or no sense of responsibility for conditions of labor and living which would not be tolerated to-day. Operatives were crowded together under unsanitary and dangerous conditions, working hours were long, and wages were governed solely by the supply and demand of an overcrowded labor market. This indifference on the part of the employers was soon met by violence and industrial warfare. At length, from various reasons, conditions began to adjust themselves. Under the leadership of such men as Lord Ashley, Robert Owen, an industrial conscience came into existence, and year by year, partly through labor legislation, partly through labor unions, partly through voluntary improvement by the employers, conditions have steadily improved, and are now better than before the introduction of machinery.

The situation was never as acute in this country as it was in England, but we know that even today we have in America industries with the most highly developed machinery where child labor and dangerous or unsanitary working conditions still exist. While conditions as a whole are by no means ideal, there has come a general acceptance of the fact that reasonable hours, good light and air, safety, and a fair wage are best not only for the worker but for the employer. Men do not agree, by any means, as to just what constitutes reasonable hours and a fair wage; but none now deny the general principle.

At the beginning of this century a new force came in, the rapidly developing art of industrial management. It is still in its infancy, yet enough has been done to show that old methods of management have been wasteful and that great increases in production are possible when the right methods have been found and put into successful operation. The invention of machinery vastly increased the workman's production by giving him new and efficient tools. The new force opens up a further increase, through the higher efficiency of the workman himself and of methods of industrial management. The effect in both cases is the same. The advent of machinery produced a profound social readjustment accompanied by widespread distress and friction. The readjustments due to the application of improved methods of management will not in all probability be as great, certainly not as drastic. Standards are far higher today than when machinery was first introduced a hundred years ago and workmen now have means of defence. Moreover, the social changes possible are probably not as radical or far reaching as in the earlier development.

The development and application of the highest types of industrial management, however, is going to be difficult and delicate work, if the results are to be made a permanent benefit to society as a whole. Those who personally direct this development will largely determine the efficiency with which "efficiency" itself is applied. If the attempt is made by those in charge to seize all the benefit of the improved methods and to crowd the advantage of the employer they will either defeat or indefinitely postpone the advance. They must be experienced men, wise, fair, thoroughly conversant with possibilities and free from sentimental idealism. This means not only a knowledge of ma-

chinery, systems, and time study, *but of human nature and the rights and real needs of industrial workers.*

The executive engineer will be at the focus of this situation. He alone is in direct personal contact with the two great elements involved, capital and labor. His thorough understanding of both of these forces will prove one of the greatest elements in progress. If the man in actual charge has little knowledge of, or sympathy with, the workman, serious missteps are certain. If on the other hand to a thorough technical training and knowledge of the resources and responsibilities of the employer, he adds an attitude of fairness and friendliness, and a personal understanding of the workman involved, the new force will work out to the good of all concerned. Scientific management offers an opportunity to pay better wages, but it will require strength and wisdom to apportion the economic gain fairly, and to maintain a just distribution of it.

Welfare work in various forms has been going on for many years, ranging all the way from improvement in the small details of working conditions to the planning and building of whole model cities. Some of these enterprises, conceived in a spirit of genuine good will, have met with no response from the workmen and in spite of the great sums of money and much thought spent on them, have ended in bitterness and disappointment. In other cases welfare work has been developed quietly and wisely, each move being tested out as it was tried and has deeply influenced the lives and social standards of the whole community. In the record of these enterprises there is a glaring discrepancy of success and failure. Most of the failures have gone onto the rocks from violation of the fundamental principles of human nature. About some there has been a fine flavor of condescension; others have been made an advertisement; others have been imposed upon workmen by authority. A workman, no matter how crude his social standards, has a right to his own personality and sooner or later he will assert it. As one of their leaders put it to the writer: "Some of these employers roll their good intentions into a big bolus and jam it down the workmen's throats saying 'Here, take that; it's good for you.'" No welfare work will ever be effective unless it is preceded by a square deal, is wrought out gradually and patiently, and is the product of mutual confidence, experience and good sense.

While thousands have been invested in welfare enterprises, we know that the purpose behind them is being accomplished in scores of industrial organizations, without any special equipment, by the personal influence of some man or men in charge. These men seem to have a genius for understanding and developing the best in those under them. They have no fixed rule or system. It is a question of attitude and personality. They create an atmosphere of confidence instead of suspicion and distrust. Their influence permeates a whole factory, kindling ambition and developing better workmen and better industrial conditions. Such men can accomplish wonders without any welfare equipment. Given a welfare equipment they make it successful and beneficial to all. Their value to the employer, to the workman, and to the community can hardly be overestimated; the new art of management under the direction of such men will prove a permanent success. The development of just such men as these is the aim of the industrial service movement.

We have tried to sketch briefly the spirit of this movement, its main activities, and its relation to the general industrial situation. It seems sound. There are at present about 30,000 students in the engineering courses of the various schools and colleges throughout the United States. Of these, perhaps 5000 to 7000 graduate each year. About 20 to 25 per cent of the students become sufficiently interested in this work to get the benefits of it. What will it mean to the employer and workman in the next generation to have coming into the management of industrial enterprises 1000 or 2000 men a year, who inspire good will and confidence and have the right point of view from the start?

Fig. 3 A Result of Industrial Service Training
An Evening Class in Practical Mining. The Teacher in Charge is a Young Assistant Superintendent who Became Interested in Industrial Work while at Yale

So far the industrial service work has been guided by experts from the industrial and student departments of the international committee of the Y.M.C.A. These men have given it special study and have directed its activities. They have kept it free from fads, and its rapid growth is perhaps the best evidence of the wisdom with which it has been directed. Although the motive which lay behind it was a religious one, it has attracted many men who took but little interest in the ordinary forms of religious activity. Many of these have found in the progress of this work that this motive and the unselfish social one are not so far apart.

In this industrial service movement, we have a large body of students giving a reasonable portion of their time voluntarily, and outside of their regular studies, to work which is an immediate benefit to others and to themselves as coming industrial leaders. It has been suggested by members of the Society that this work might be fostered as one of the activities of the Student Branches. If so, it should be wisely and carefully directed. The experience and training which its present leaders have acquired would be available and can be called on to help organize and guide it. The work of the Student Branches is good, but they have much greater possibilities than we have yet realized. At present their main, if not sole, activity has been to arrange a series of engineering lectures, which is well as far as it goes. Some such work as this industrial service in addition would strengthen their usefulness and bring in the human element which the curriculum cannot give.

DISCUSSION

L. P. Alford. Professor Roe asked me to make one suggestion in his name in regard to the work of the Student Branches. It is that there might well be some person connected with the Secretary's office charged with the duty of visiting the Student Branches as often as necessary with this purpose. The members of this Society are employers of cadet engineers. The Student Branches are training these young engineers for full membership in the Society after they have reached the proper age and acquired the necessary experience. Through the medium of this official of the Society working with the Student Branches, it might be possible to modify and improve the training of young engineers to their advantage, to the advantage of their first employers and further to the advantage of members of this Society.

P. F. Walker. I have had the Student Section at the University of Kansas under my charge ever since 1909, when the section plan was put into effect, and I believe thoroughly in what Mr. Alford has suggested. I remember very distinctly the enthusiasm with which my boys greeted Secretary Rice two or three years ago when he came out to visit us.

With regard to Professor Roe's paper, I think the plan suggested is one that may be readily applied in the cases of sections connected with institutions located in large centers, but those of us who are in institutions located in smaller towns will have to employ different methods. One method which I believe to be workable, is based on the plan of University Extension work which Kansas, along with Wisconsin and other western universities, is developing. Vocational courses of study adapted to the needs of boys and young men engaged in the various industries of the state, are outlined. Through these, they receive instruction in the rudiments of mathematics and the sciences related to engineering, together with first principles in their application to construction work. I expect to have two or three of my seniors in mechanical engineering working as instructors in this connection next year. I mention this as a suggestion for those institutions not situated in the large manufacturing centers. The general plan brought out in the paper is a most happy suggestion, and one which may well engage the attention of the Society.

H. L. Gantt. I do not think that the membership at large has any idea of the importance of this paper. The most important problem before the industrial community today is that of the relation between the employer and employee. The reason why this is so is because the employer and employee do not understand each other.

The plan suggested to bring the employer and employee together, is the most promising step that I have seen or heard of. We see in the papers every now and then what somebody in the American Manufacturers' Association says about what the Unions are doing to them. They do not say a word about what they are doing to the Unions. That is because they do not understand each other. Foreigners who come to this country do not understand us; we do not understand them. To many of us, they are simply "Dagos" or "Hunks," to be treated as somebody in authority sees fit. Now, the activities which Professor Roe has described will bring the engineer of the future in contact with all of these people and give him a knowledge of who they are, what they are, and what they can do. I find that the Hungarian, the Pole or the Italian is very much like anybody else when you really know him.

Some time ago the following incident of interest took place. There was great dissatisfaction in a place where I was doing some work, and I investigated to see what the trouble was. My man had been there and everything was going very smoothly when he left; soon afterward, I found a good deal of trouble. On investigation, I found that the management had not carried out the promises which they had made, and their people were on the verge of a strike. My man was telegraphed for and succeeded in straightening things out as soon as the management made good their promises. Nobody had taken the trouble to find out just what the matter was. No one had talked with the workmen who, in my opinion, were absolutely right. As soon as the management began to recognize the actual conditions, the whole matter was cleared up.

Workmen are in one class and employers in another, and, as they do not know each other, they cannot, or will not, talk to each other. So long as that condition prevails, we are not going to solve our industrial problems without some connecting link. The work that Professor Roe is doing is going to turn out a lot of young engineers who will learn something about the human nature with which they have to deal and supply this link. In the ordinary college course, the student gets a lot of mathematics and engineering, all from the book end. Then he goes out on a job and sees the mechanical processes. He can learn those mechanical processes a great deal quicker than he can learn the human beings who have to operate them. You may build the best mechanism in the world, but some human being has to operate it, and if you have not a knowledge of the kind of human being who is to operate it, you are going to get into trouble.

The term—scientific management—is used in this paper: it means the utilization of scientific methods of investigation in the art of management. You can build up a system of management which is perfect, just as you can build a fine steam engine or automobile, but unless you have the right

personality to run it, you are just as likely to wreck it as you are to wreck the automobile or steam engine by putting an incompetent person in to handle it. Some time ago, a publisher asked me why certain books he was getting out did not sell; he had been writing papers or publishing articles on management. The reason was that he had not yet grasped the idea that a system of management is a mechanism, all parts of which work together harmoniously. He had seen a little stunt that somebody did, and had published an account of that; he had seen a stunt somebody else did, and published an account of that; he had stunts from everywhere, and his paper was filled with these stunts that had no relation whatever one to the other. They might have represented a dozen systems of management, each one a good one, but the stunts that were good in one system did not fit in the other. To illustrate what he was doing, take a picture and jigsaw it into pieces. If you have only one picture, many people can take these pieces and put them together correctly. If, however, you take six pictures and cut them up into small pieces and put them into one pile, the problem of making a complete picture from this pile is far more difficult. If you deal out these pieces indiscriminately a few at a time, the probability of making any picture complete seems hardly worth considering. Nobody would buy such pieces, no matter how much interest he had in the subject.

The flaw in the present way of trying to develop industrial management is very similar to the above. The editor cited is trying to sell pieces of systems of management not in sets, but all mixed up together. In constructing a system of management, one must first have an ideal which must be based on the knowledge of human nature as well as on a knowledge of mechanical operations and appliances. Professor Roe and his co-workers are giving their students the fundamental ideas of how to handle their workmen. It is very much better to have a man who knows how to handle the workmen using a comparatively poor system of management, than it is to have somebody who does not know how to handle the workmen with a fine system of management. The first will get along better than the second, and I want to emphasize that this training of the engineering student in a knowledge of the human nature with which he has to deal, to my mind, ranks in equal importance with strictly engineering training.

C. W. Rice. In response to the suggestion of Professor Roe that the Secretary arrange to visit the Student Branches, your Secretary tries to be up to date in every realm of activity of the members. As soon as I heard, two years ago, of this work of Professor Roe, I wrote a personal letter to every head of a mechanical engineering department in each of the schools in America where it is taught, and you would be pleased to see the magnificent responses that were received, showing that they are all alive to this movement. As a suggestion, I think that speaking for Professor Walker, as representing the Student Branches, he would be glad to have also the members of the Society visit him—men of affairs. I think there is nothing so attractive to the average student as to have a real man with a reputation, come and visit the school and give a talk.

The effect would be two-fold. You would have the interest of more members of the Society in that work and you would have more interest on the part of the Student Branches because men of affairs were interested in them. Now another suggestion has come to me with respect to students, which can be accomplished by every person in the room and by every person with whom you speak when you get home—and that is, the benefit of these conventions. Every person here must be in some organization. You must have men in your employ who are just out of college or who are just starting in your organization, lacking experience. Try to co-ordinate them with the university in your town or with some organization in your town which is doing this class of work. You will have a two-fold benefit from this interest. First, your men in your employ will become more useful to you because they understand men better, and second, the men in whom they become interested will also become better employees for you.

When I first started out in 1889, I got in line at the window to take a job, and the man directly following me became a sweeper, while I commenced to file off the paper between the laminations of transformers. In the course of time, I was promoted to foreman of a room and the man who was a sweeper still continued as a sweeper. In after years I went back to that factory and found that man was still sweeping up in the yards. Now the difference was one of inspiration and of opportunity. If we interest our young men to take the time to instruct the more ordinary laborers, they become more valuable than sweepers in the course of three or four years. We must educate our men to be continuous in our employ as useful workmen, rather than continue as sweepers, and education is the only way in which you can do it. I want to urge each one of you to take the spirit of this paper of Professor Roe and apply it to your own factory now rather than to think it is something for somebody else to do in some university.

P. F. Walker. There is one other thought in connection with the Student Section and what it may mean in the life and work of the Society, that I would like to lay before you by explaining what we have done at Kansas. Each year, usually in December, we hold our annual meeting. There is no organized local section of the society membership nearer to us than St. Louis, but we are only forty miles from Kansas City where there are nearly twenty members. As many more are scattered in other cities in the state. At these annual meetings of the Student Section, we make a special point of inviting every member of the Society who is within reasonable distance, and some of them always come. I speak of this as a suggestion, indicating what the Society might do in the way of recognizing the Student Section centers as nuclei for local sections of the Society for the regions adjacent, when the location is distant from those cities where a full local section organization is practicable.

L. P. Alford. I feel impelled to say another word in the name of Professor Roe. I know that in making this suggestion he has had no thought whatever that there has been a lack of coöperation between the Secretary's office and the Student Branches. It is not that at all. He has been merely trying to point out the possibility of further and new activities and suggesting the way in which some of these can be initiated. Personally, I am most heartily in sympathy with the suggestion of Mr. Rice that some members of the Coun-

cil or other members of the Society take occasion to visit and address the Student Branches.

Professor Roe's paper does not reveal his personal connection with this great movement. He is its Father. He is the man through whose far-sightedness and initiative the work was started. He deserves a generous measure of our esteem and commendation for having inaugurated a social movement in our engineering colleges that promises to be of great benefit to engineers and industry.

H. L. Gantt. To visit these Student Branches and start this working going, will cost something. You cannot do any of these things without money. I feel that many manufacturers would be willing to put up money for the advancement of the Society. Somebody has suggested that we might have manufacturers who are contributing members or something of that kind. This suggestion is well worth considering. The possibilities of the engineer as an economic factor, have been emphasized most clearly within the last twelve hours, but we need money to make them realities. All we need now is to have some way of financing this growth which seems to have started with such a rush.

Paul Doty. I think that most employers, at least modern employers, recognize their obligations in connection with the general subject of welfare work. The thought that "a man is his brother's keeper" does seem to permeate the minds of a good many employers. We have here in St. Paul in our company work, an employees' club, formerly called The Technic Club. We have some educational work, some welfare work, we have talks on "safety first," on efficiency and we also have talks covering good management and some on bad management. We try to make these meetings of employees of vital interest to them. We bring home homely suggestions—we bring home their work-a-day life. These meetings are held as frequently as necessary, at least once a month, and in addition to the practical side of the work, the construction, the manufacture, the distribution—all the operations of the property—we have the social side, a dance occasionally, a picnic now and then and an excursion during the summer season—something that will maintain the human interest, and bring together the employer and employee.

We try to have a sense of the need of the understanding which Mr. Gantt has referred to. We know that employers without employees could accomplish very little, especially in continuous service business like public utilities when twenty-four hours a day, three hundred and sixty-five days a year, somebody is working somewhere with us, and we need something outside of the mere payment of wages as compensation to the employee. I do not go so far at the present moment as to refer to service pensions or service annuities, or profit sharing, or other form of welfare work as it is understood generally, but all those things we do have in mind.

The educational work is particularly important and is under men like Mr. Walter C. Beckjord and his associates. A few years ago, Mr. Beckjord was a student at the University of Minnesota and came to us as one of our cadet engineers. We have that feature established to bring about the training of the younger men, and through years of faithful service, he is now occupying a position of responsibility and has been President of the branch of our educational work including both the gas and the electrical departments.

We claim no special credit for the work we are trying to do. It is work that is being advocated by the National Electric Light Association. It has been recommended by Mr. Insull, President of the Commonwealth-Edison Company, who has suggested that educational work be carried on in the time of the employer, not only the time of the employee—after hours—when a man perhaps is tired and does not care to come out; but that hours be set aside from the employer's time for this educational work. That, I think, is a wonderful step forward—where a man recognizes the responsibility to employees to give time for educational work on the company's payroll. The movement is here. It is the coöperative movement and we must, as progressive men, progressive engineers, recognize that there is work for us to do along this line. We are not wholly discharging our obligations by the giving of the pay check or the pay envelope at the end of the week or the two weeks' period.

H. L. Gantt. Professor Roe does not regard this as welfare work. Welfare work, as I understand it, is something done by the employer for the employee. Now, personally, I am not a tremendous advocate of welfare work as such. Professor Roe says here: "A workman, no matter how crude his social standards, has a right to his own personality and sooner or later he will assert it. As one of their leaders put it to the writer: 'Some of these employers roll their good intentions into a big bolus and jam it down the workmen's throats saying "Here, take that; it's good for you."'" While I have no idea that Mr. Doty has any reference to welfare work of that character, yet there is a good deal of so-called welfare work that is strictly of that character, sometimes with the best intentions in the world. The work which Professor Roe is doing is not in this class and seems to me to be at the root of our industrial progress. The gap between employer and employee will widen, if we do not do anything to close it up. It is just equally important to public interests and to the interests of the employer, to those of the engineer and to those of the employee that this work be done.

James Hartness (written). I have read this paper entitled "Industrial Service Work in Engineering Schools" with keenest interest and pleasure. I am in most hearty accord with the central motive and am confident that it will have a far reaching and beneficial effect not only on the undergraduates, but on all engineers who are in receptive condition for progressive ideas.

The engineer should be in the forefront of the campaign for bringing people together—not only people of different nations, but people of different walks of life. The trend of the public's social and economic views will begin to turn upward as soon as these various peoples begin to understand each other. But so long as the workman fails to understand the business man, and the business man the worker, the trend of our ideas will be toward anarchy.

The paper should serve as a keynote for many others that will bring out the great importance of this fact, for it is the engineer, who, as the director of men, is in the position to put into practical effect many regulations that will lead to a better relation and a better understanding between man and man.

This can be truly called welfare work, but it should not carry with it the impression that it is solely for the laborer or even for the newly arrived immigrant, for it is as truly welfare work among the well-to-do.

Our success as engineers will be greater if we work along these lines and the value of the engineer to his country will be beyond measure if he realizes his obligations and opportunities along the lines stated.

Although the paper sets forth this work in its bearing on the student and the humblest workers, it will carry to every one the message that there are opportunities of this kind not only between the business man and the worker, but also between the workers of different grades when measured according to their skill and knowledge.

I congratulate the writer on presenting this subject to our Society and hope that it will be followed by others tending to offset the present unfortunate trend of class feeling in this country, for much harm and very little good will be obtained by any scheme that fails to take into consideration that each man has a heart as well as a brain, and that each man may best be directed by someone in whom he has confidence, by someone who understands him and that the physical energies of man must be directed through the man's inner self. You must get at his inner motive instead of trying to forcibly impress his body into service.

The Author. So far from implying criticism, the suggestion referred to in the discussion sprang from the very effectiveness of Mr. Rice's relations to the Student Branches. No one knows better than the engineering instructor his interest in the Branches, or the value of his visits to engineering schools. But, as the chief executive officer of the Society, the Secretary has the responsibility for many activities, of which the Branches constitute but one. The President and Council members are men of important outside interests. None of the officers of the Society are in a position to give all, or even a large portion, of their time to the Branches, even if they would.

And yet there is a great field there. The Branches are increasing in number and membership. Their value, already demonstrated, may be greatly enlarged; and the good work done by the Society under existing conditions justifies an extension of its activity. The present officers cannot, in justice to their other responsibilities, however, be called on for a very much greater contribution of time than they are now giving.

What is suggested, therefore, is a salaried officer of the Society, who should be a college man of experience, wide acquaintance and constructive ability, who would, under Mr. Rice's direction, organize Student Branches and supervise their activities, bring the officers and active members into closer relations with engineering students, assist in arranging schedules of speakers, help students in securing wise summer employment, and inquire into and develop such new activities as this Industrial Service work, which the writer believes to be of sufficient promise to justify, of itself, the step proposed. But it is a work which is expert in nature and must be guided wisely to keep it free from fads and the mistakes of immature enthusiasm.

This program is merely a suggestion. The right man would materially extend the field as his work progressed. Like the education, with which it would be allied, it would be constructive work for the fufure and its influence would be most felt in the next generation.

GEAR TESTING MACHINE

By WILFRED LEWIS, PHILADELPHIA, PA.

Member of the Society

The gear testing machine, shown in Fig. 1, is the result of the writer's efforts to realize in concrete form an ideal machine for the purpose of continuing the experiments reported to the Society by Prof. Guido H. Marx at the Annual Meeting in 1912. The possibility of testing heavier gears at higher speeds with comparatively little power occurred at once to Mr. Ralph E. Flanders and to the writer as pointed out in their discussions of the paper, but the problem remained to design a suitable machine which might also be used to supplement the experiments made by the Committee on Standards for Involute Gears to determine the friction losses and the running qualities of various types of gearing. After making a number of preliminary sketches, the writer was about to put them in the hands of a draftsman, when he had the good fortune to meet Prof. E. P. Lesley, one of Professor Marx's associates, who accepted the task of preparing the working drawing. The machine as it now appears is due in large measure to his careful attention and skill in the perfection of every detail and the writer is pleased to acknowledge many helpful suggestions which have broadened the scope of the undertaking and made the design a practical possibility.

The machine proposed is based essentially upon the principle of the machine used in testing by the Committee on Involute Gears, which is to put the teeth under a working load without consuming an excessive amount of power. The design, however, has been modified to facilitate changes in the working load and in the test gears employed. At the suggestion of Professor Lesley, it has also become possible, not only to change the amount of the working load while running, but also to change its direction, thus producing the effect of reversing loads upon the teeth while running continuously in the same direction.

The apparatus has a hollow shaft made in two parts, A_1 and A_2, united by a clamp A_3, also made in two parts to facilitate assembling. At one end of this hollow shaft is a flange to receive the steel gear ring G, which serves as a permanent part of the apparatus and is strong enough to resist the stresses due to testing.

Besides the hollow shaft A, there are two solid shafts C and S on which are mounted the gears or pinions to be tested. Shaft S passes through hollow shaft A and has a flange, at one end of which is mounted test gear T. Shaft C, parallel with shafts A and S, carries the wide-faced pinion P, which is in mesh with both the permanent gear ring G and test gear T.

Shafts A and S are connected at their opposite ends by a novel device through which any desired amount of

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load in either direction can be applied to the teeth, whether at rest or while running in either direction. To accomplish this purpose, the hollow shaft A is flanged to receive the pneumatic cylinder M, in which is the piston N, firmly secured to the shaft S. Pins D D are driven into the piston N through the openings in the cylinder M and upon the projecting ends of these pins rollers R R are mounted upon roller bearings. A bolt passing through the pins, piston and shaft secures the whole in place. These rollers R R engage helical segments H H let into the walls of the cylinder M. Air pressure can be applied to the piston N on either side to give a slight amount of end motion to the shaft S and so, through the action of the rollers upon the helical segments, a slight angular motion is produced between shafts A and S, resulting in a pressure between the teeth of the gears upon these shafts and the teeth of the pinion on shaft C. Pressure gages O_1 O_2 connecting with each side of the piston area are calibrated to record the resulting pressure on the gear teeth, taking account of the piston areas, the pitch of the helical cams H and the diameter of the gear wheels.

Since but little power is required to drive the apparatus, the pinion P is simply clamped to the shaft C, by a nut on its tapered end. The shaft itself is made heavy for the sake of stiffness and a pulley O, between bearings, is attached for driving from a countershaft, or if preferred, a motor drive may be used in connection with the extended end. When the gear wheel T is to be tested, the intention is to use it in connection with a steel pinion; and when the pinion P is to be tested, the intention is to make it of cast iron and cut down the width of the teeth engaging with T, by nicking down on either side to a smaller width of face.

When a tooth breaks in the wheel T, or in the pinion P, it is important to avoid the complete destruction of the apparatus by the jamming of the remaining teeth on their ends, to maintain the wheels G and T in proper relation to each other, and for this reason, the stops K K, with their adjustable eccentrics E E, are employed. The block K is clamped to the wheel G through the intervening eccentric bushings E E. The intention is to keep one of the clamping bolts tight while the other is loosened and the eccentric adjusted to a predetermined amount of clearance on either side, after which both eccentrics are to be clamped. These stops do not come into action unless a tooth is broken or deformed. Then they cause both gears, G and T, to run together. By means of these stops it is also possible to study the effect of a predetermined irregularity in forming or spacing the teeth. For instance, an abnormally wide space or tooth can be simulated, when broken out or purposely cut away, by the position of the stops and the pounding effect in running will be

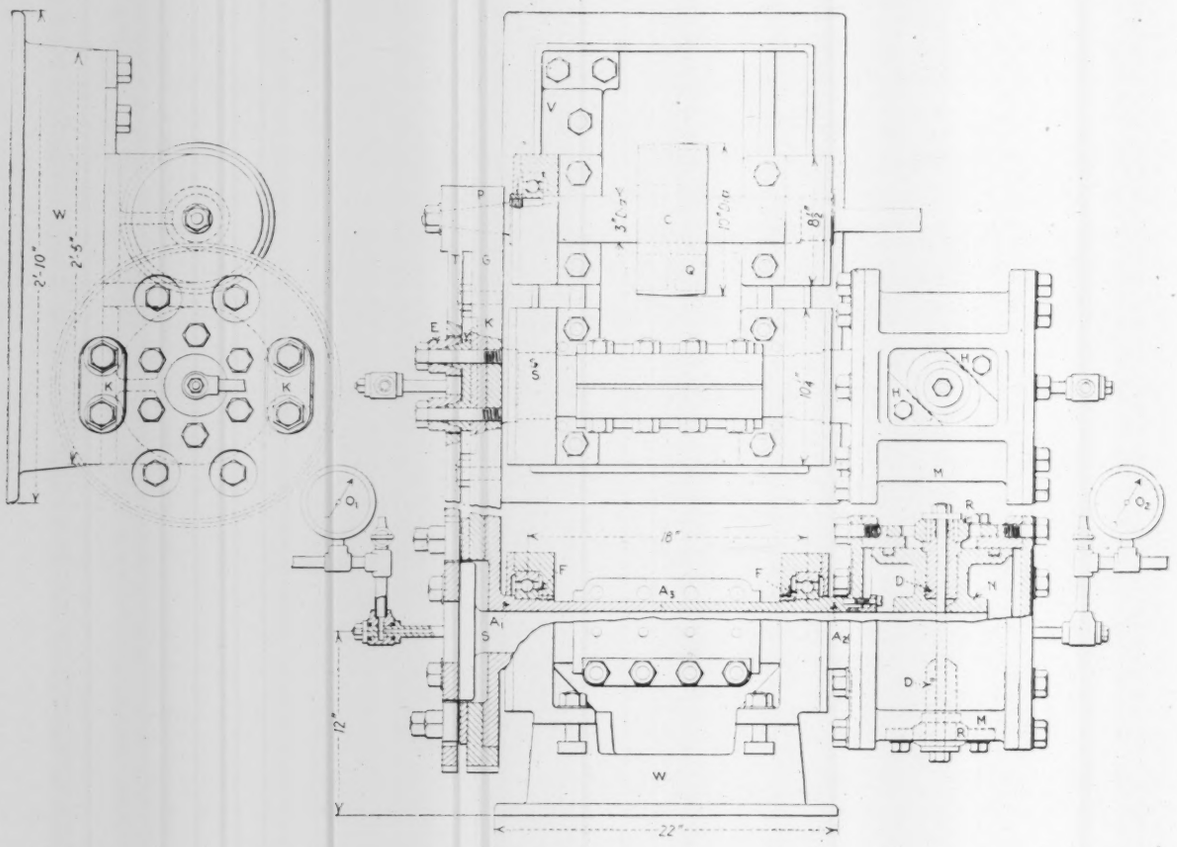

Fig. 1 Gear Testing Machine

evident as the result of a certain measured irregularity.

The shafts A and C are mounted in ball bearings to reduce friction and as a matter of expediency the scale of the apparatus has been determined by the bearings F F on the shaft A. These are of the largest commercial size and to make them available the shaft A was cut in two and united by the clamp A_2. The bearings for the hollow shaft are firmly bolted and doweled to a bed plate W, while those for the pinion shaft are adjustable to the diameter of the pinion used, a distance piece V of proper width being used in every case to prevent movement under load.

It will be seen that the apparatus is capable of determining to a nice degree of accuracy a number of unsettled problems of great practical importance at a very small expenditure for wear and tear and power. Jigs will be made for drilling the gears G and T after cutting the teeth, so that the relative positions of the two wheels may be accurately fixed. Friction is practically eliminated in the ball and roller bearings, and what remains must become inappreciable under the well-known influence of vibration when running, except that due to air resistance and the friction in the teeth. With some accurate means for measuring the power consumed, both of these variables can be determined better than ever before. The apparatus in skilful hands should therefore solve the mooted question of the effect of speed on strength, and questions of durability, wear and noise can be studied at a small outlay in power and materials. It is possible that some slight modifications may finally be embodied to facilitate construction, but the machine so shown is believed to contain the elements needed for an exhaustive examination of the subject of gearing in all its phases and the writer hopes it will appeal to some one interested, who has the means to build it and time to experiment on the lines so well indicated by Professor Marx.

DISCUSSION

Elmer H. Neff: As I understand it this paper is simply a record of a design which has never been built. It would appear therefore that the real discussion of this machine will be brought out when it has been built and an attempt made to draw conclusions from experiments made with the machine. At that time more details will be apparent than a hasty examination reveals. We will be able to judge somewhat of the statement in the last paragraph suggesting that vibration reduces the quantity of helical friction loss in the machine to a negligible quantity, leaving only the friction of the gears as they exist.

Henry Hess: Mr. Lewis has done a really extraordinary amount of self-sacrificing work in this line, for which he has earned chiefly criticism, largely interested criticism, but criticism nevertheless. There is probably no other one man who has given so much time and effort with absolutely no incentive of a financial reward of any kind and with no interest except a purely engineering one. It would be a very good thing if it were possible for the Society to make available surplus funds, which it has not at present, but which it may hope to have some day, for the prosecution of experiments with a machine such as this of Mr. Lewis' design. I do not mean to say necessarily this particular machine, but any machine which will realize the object underlying its design. I move that the Society suggest to the Council, the initiation of steps to render possible the carrying out of experiments of this character.

P. F. Walker: It may be of interest to some to know that in the engineering laboratory at the University of Kansas we have under way tests to determine the friction loss in gears. Our plans cover more than the gears, however, our first work having been on the universal joint as made for automobile transmission. On this latter portion of our work I had thought to comment to-day, since it will be some months before our work on the gears will be brought to a point where any report may be made.

The point of greatest difficulty in the measurement of friction losses is in the measurement of power. Where the power transmitted is in fairly large amount and the friction loss small, and the power input and power output are measured in their full amounts, the small difference indicating friction loss is bound to absorb all errors. The error may be a small percentage of the power transmitted and still be so large in proportion to the loss being determined as to render results worthless.

For this reason, in the universal joint work we adopted the "Load-back" method of testing. This consists in operating the joint between two electrical machines, the shafts being connected through the joint, one machine acting as motor and the other as generator while the first uses the current generated in the second. The only power supplied from outside is that required to make up the losses of machines and joint combined. The machine losses must, it is manifest, be determined separately, but a distinct advantage gained is the elimination of the large power readings. In any form of test the machine losses must be determined, thus introducing that detail in the work irrespective of other determinations.

We have spent three years on the universal joints and have gotten to the point where we are about ready to make the report. On the gears, only the preliminary runs have been made, but I have reason to believe that this work will progress much faster than the other.

A. G. Christie: It may be of interest to know that a number of the large state institutions in the West have engineering experiment stations in connection with the University. Illinois, Wisconsin and Iowa, all have experimental stations in connection with their state University. These experimental stations are not tremendously wealthy, but they do have each year certain sums of money set aside for investigation work, and I believe that a great deal could be gained both by the stations and by the Society, if the Society would coöperate with these engineering experiment stations in carrying on research work. While I was at the University of Wisconsin we would have welcomed such coöperation very greatly. In fact we did carry out some work suggested by the ventilating engineers. I believe the universities would welcome any suggestions coming from the Society.

The Author: It is true, as Mr. Neff has stated, that the

gear testing machine described in my paper has never been built. It is simply a design intended to meet the need of further light upon a number of questions pertaining to the use of gears. As suggested by Prof. Walker, there are other ways of measuring the friction losses in gearing, and if good results can be obtained by electrical methods, it will be interesting to have such experiments for comparison.

There are, however, other features of this testing machine which do not appear to be so easily superseded by a motor driven generator, and it is difficult to imagine how the load on the teeth can be varied and reversed with the same facility and measured with the same precision. Nor does it appear how the effects of irregularities in forming and spacing the teeth can be so carefully studied under different speeds and loads. Perhaps the same problems can be solved to advantage in other ways, and different methods of attack are certainly to be desired, but the direct mechanical method appeals to me as the most accurate and reliable. Friction can be practically eliminated by ball and roller bearings and if the little that remains is not further reduced to a negligible quantity by vibration, it is reassuring to know that the conclusions will not be seriously affected thereby. Vibration of a pattern on a molding machine certainly does eliminate most of the friction between that pattern and the sand, and it is well known that bolts and nuts work loose in machinery subject to vibration, unless special precautions are taken to secure them.

If the interest in the subject warrants the construction of a machine, as implied in the motion of Mr. Hess, by all means let us have the type of machine subjected to the fullest and freest discussion. I have simply presented a design which appears to me to be complete and satisfactory, and I shall be glad to welcome other ways and means upon their merits.

A FLOW METERING APPARATUS

BY A. M. LEVIN, CHICAGO, ILL.

Member of the Society

The pitot tube and venturi meter, while fully reliable, with proper handling, for determining the flow in closed channels, are apt to give more or less doubtful results in less experienced hands. An apparatus less sensitive to errors and, in a majority of cases, quite easy to install, is the elbow or bend meter described in this paper. The principle on which the measurement of flow in this apparatus is based, is that when the velocity of a fluid, as a whole or in part, is changed, a change in pressure accompanies the change in velocity, and hence, when the areas carrying the fluid before and after the change are known, the original and final velocities of the fluid can be determined from the change in the pressure that has been noted. The apparatus (Fig. 1) consists simply of an elbow or bend provided with suitable pressure ports in the inner and outer curved walls, by means of which the centrifugal action set up in deflecting the course of the passing fluid is communicated to the registering apparatus.

FORMULAE RELATING TO THE FLOW BEND

If it be assumed that, when passing through the bend, the velocity in each stream line is proportional to the distance from the center of curvature, so that all particles of the fluid in the plane normal to the neutral axis move together, then the centrifugal action normal to the axis will be as illustrated in Fig. 2.

Here m is an elementary mass of the fluid, of a sectional area a normal to the diameter DD and of a length dx. In turning the bend, the centrifugal force C, acting on m will cause the pressure acting radially in front of it to be increased the amount dp, and the increase in pressure on the area a must at all instants balance the force C. Hence, we have

$$adp = C = mxw^2$$

and since

$$m = \frac{\delta}{g} adx$$

we get

$$\frac{dp}{\delta} = \frac{w^2}{g} xdx$$

With respect to the density δ in the above equation, the following assumptions may be made:

I That δ remains unchanged during the flow, as in the case of water

II That δ changes at the rate an isothermal compression or expansion would call for

III That it changes at the rate an adiabatic compression or expansion would call for

Case I. δ is constant. Through integration of the general equation

$$\frac{1}{\delta}\int_{p=p_1}^{p=p_2} dp = \frac{w^2}{g}\int_{x=r}^{x=R} xdx$$

after certain substitutions, with V_m as the mean linear velocity, there will be obtained

$$\frac{V_m^2}{2g} = \frac{R+r}{4(R-r)}(h_2 - h_1)$$

Finally call $R - r = D =$ the diameter, or width of the channel and $\rho = \frac{R+r}{2} =$ mean radius of the bend, then we get

$$\frac{V_m^2}{2g} = \frac{\rho}{2D}(h_2 - h_1)$$

which may be written

Abstract of paper presented at the Spring Meeting, at St. Paul-Minneapolis, 1914, of The American Society of Mechanical Engineers.

$$V_m = \sqrt{\frac{\rho}{2D}}\sqrt{2gH}$$

where H is the difference in the pressure at the outer and inner wall of the bend, in feet head of the fluid.

The corresponding formula for the pitot tube is

$$v = \sqrt{2gH}$$

Hence, the velocity measured by the bend will be $\sqrt{\frac{\rho}{2D}}$ of the velocity measured by the pitot tube for equal differential pressure. In other words, the differential pressure in the manometer tube will for the same velocity of the fluid be $\frac{2D}{\rho}$ of the pressure indicated by the pitot tube.

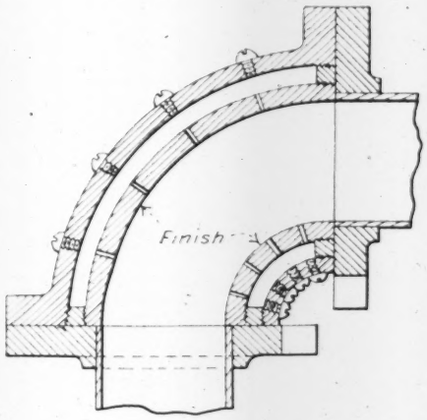

Fig. 1 Metering Bend

Case II. δ changes as by isothermal compression. Hence

$$\delta = \frac{P}{P_1}\delta_1$$

which substituted in the general equation gives

$$\frac{P_1}{\delta}\int_{p_1}^{p=p_2}\frac{dp}{p} = \frac{w^2}{g}\int_{x=r}^{x=R} x\,dx$$

and through integration and reduction

$$V_m = \sqrt{\frac{\rho}{2D}}\sqrt{2g.144\frac{p_1}{\delta_1}\log_e\frac{p_2}{p_1}}$$

Case III. δ changes as by adiabatic compression. Accordingly,

$$\delta = \left(\frac{P}{P_1}\right)^{\frac{1}{n}}\delta_1$$

which substituted in the general equation gives through integration and reduction, as previously

$$V_m = \sqrt{\frac{\rho}{2D}}\sqrt{2g.144\,\frac{p_1}{\delta_1}\cdot\frac{n}{n-1}\left[\left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}} - 1\right]}$$

Hence, the general formulae for the bend are practically those of the pitot tube covering corresponding cases, with only the factor $\sqrt{\frac{\rho}{D2}}$ added, so that, strictly speaking, the use of the bend does not introduce any really new formulæ.

In order to determine what results could be obtained by the use of the flow bend, investigations were made with a special apparatus designed for this purpose, steam being used as the fluid under test. In Fig. 3 are plotted the weight of steam per minute on a base-line which is the product of height of water-column, in inches, by the corrected density of the steam.

The bend was of a sectional area of 1.24 sq. in., and was attached in a 1½-in. steam line, with one throttling valve in front and one behind it, whereby the pressure and the velocity of the flowing steam could be regulated at will. At the time of planning for the apparatus it was hardly expected that the abrupt change in area, from a cylindrical tube 1.6 in. in diameter to a square tube 1⅛ in. on a side would be productive of the very best results. However, it was reasoned that as the centrifugal force is more or less independent of whirls in the body of the fluid, any irregularities in the flow would not have as great an

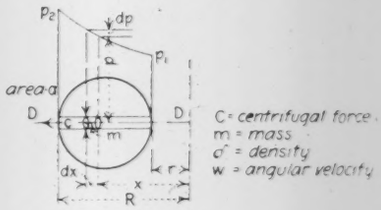

Fig. 2 Diagram of Motion of a Particle of Fluid in the Flow Bend

influence on the results as it would in the case of the pitot tube or in the venturi meter. It was also assumed that the great number of pressure ports lengthwise of the bend would have a tendency to average up the possibly varying pressures throughout its length. Besides, it was in part the object of the investigation to determine if violent irregularities in the flow really would have any great influence on the readings; because on that circumstance would depend, largely, the final usefulness of the apparatus, as compared with that of those in general use.

From the pitot tube formula, the corresponding formula for the bend may be obtained, as explained, by adjoining the factor $\sqrt{\frac{\rho}{2D}}$. Thus, for the present case

$$W_m = 7.62\,a\sqrt{\frac{\rho}{2D}}\sqrt{h_w\delta}$$

where W_m is the weight in lb. per minute, and h_w head in inches of water. The average area through the bend was 1.24 sq. in.; the factor $\frac{\rho}{2D} = \frac{2}{3}$, or $\sqrt{\frac{\rho}{2D}} = 0.8165$. Hence, for the bend used we have

$$W_m = 7.62 \times 1.24 \times 0.8165\sqrt{h_w\delta} = 7.716\sqrt{h_w\delta}$$

This formula is represented by the full-drawn curve of Fig. 3.

The approximate velocity formula, which applies quite closely for steam of the moderate velocities of the present tests, may be written from formula for the pitot tube, as

$$v_s = 0.8165 \times 18.29 \sqrt{\frac{h_w}{\delta}} = 14.93 \sqrt{\frac{h_w}{\delta}}$$

The curve representing this formula (the parabola) is shown in Fig. 4, and underneath are plotted, in feet

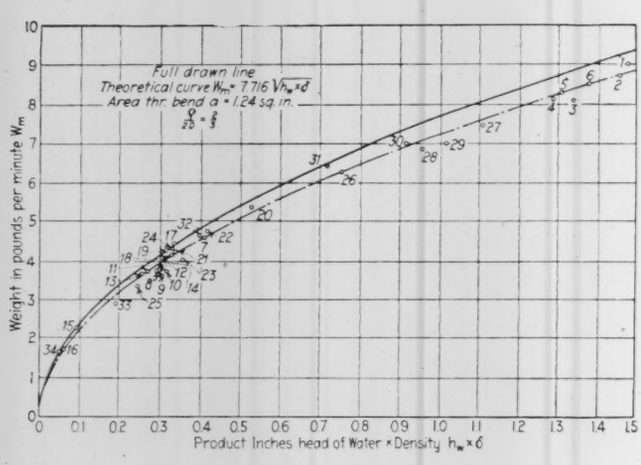

Fig. 3 Curves of Weight per Minute

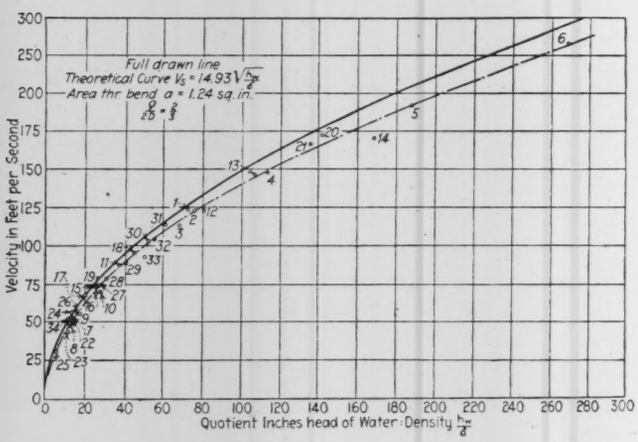

Fig. 4 Velocity Curves

per second, the velocities obtained in the 34 tests. The average velocity curve to suit the plotted points would be approximately as shown in the broken line, and it will be seen that the majority of the plotted points come as closely to their proper places as could reasonably be expected. It may be said that on the whole and under the circumstances, the results come surprisingly close to what the theory would have predicted; and it is judged that with reasonable care to eliminate as much as possible all disturbing influences with respect to the flow through it, the bend will in accuracy measure up well with the instruments in general use.

DISCUSSION

S. M. Woodward. This is an interesting matter and the instrument as explained seems to have given good practical results, but I doubt whether the correct theory of flow around the bend is as simple as the mathematics given in the paper would indicate. One of the fundamental assumptions made, is that in a fluid flowing around the bend, all the particles have the same angular velocity. It seems to me that it would be more rational to assume the same linear velocity. This would not affect the practical use of the apparatus but it would somewhat affect the calibration.

Flow around bends is a complicated matter. As motion around the bend begins and the pressure becomes less on the inner boundary of the curve, this change of pressure is accompanied by a corresponding change in velocity distribution through the cross section. At first, the diminution of pressure produces an increase of velocity on the inner side of the bend, which is the opposite of the condition assumed in the paper.

The Author. I readily agree with Professor Woodward that the theory for flow through bends is, in its entirety, quite complicated; but in so far as it pertains simply to the centrifugal force coming into play it does not seem, necessarily, involved at all. The matter to which Mr. Woodward refers, I should perhaps have stated more fully, in order to be more readily understood.

The force acting on a given section of the fluid, and causing it to deviate its course is, successively, changing in direction as the fluid proceeds through the bend, but it always passes through the center of curvature of the bend. Its effect, therefore, upon the fluid, at any time throughout the sweep of the bend, will be a certain force through the center of curvature, the centrifugal force, and a couple, which latter causes a whirl or eddy. But as far as the centrifugal force is concerned the whirl is of no consequence whatever.

With this in view, the assumption with regard to the stream lines of Fig. 3 would, of course, better be looked upon as referring to particles of the fluid of certain defined density, rather than strictly to some mathematically defined material points. However, any way this may be looked upon, under the conditions of the problem the assumption seems justified, and that it really is so the results verify.

With regard to the elementary section through the fluid, Fig. 2, which is the basis for the deduction of the formulas, there is no necessity for considering it as being composed of the identically same material points for every section of the bend. That various particles may replace each other from section to section does not affect the reasoning, so long as they change position in a manner that will not affect the centrifugal force.

The substance of the proposition may, perhaps, be stated simply thus: There is a certain mass passing through the bend, the center of gravity of which is located, and of known velocity; there is then, in order to find the value of the centrifugal force, no need for knowing whether the mass revolves, or how it acts, so long as its center of gravity follows a defined path.

Mr. Woodward's statement that the velocity of the fluid increases on the inner boundary of the bend as the pressure decreases, I can explain only on the ground that he refers to the velocity in the whirl. I have by "velocity" considered only that which causes the fluid to progress through the bend.

RAILROAD TRACK SCALE

BY W. WALLACE BOYD, BALTIMORE, MD.

Junior Member of the Society

The immense freight traffic of the railroads, with the necessity of interchanging cars in order that the merchandise which they contain may reach its destination without transfer, demands an accurate method of determining the weight of the loaded car as it stands upon the rails.

In order properly to weigh these loads, track scales of sufficient capacity and length must be supplied at the necessary points along the route; and above all, these scales must be of such construction as to put their continued accuracy beyond a doubt.

In these scales the following essential conditions must be observed:

a The foundations must be massive enough to resist successfully distortion or displacement due to repeated applications of the load.

b Connections should be strong enough to resist the load imposed upon them even after considerable corrosion has occurred.

c Unnecessary friction must be eliminated since it produces sluggishness of action, insensitiveness to the smaller loads and inaccuracy in indicating the load.

d There must be a proper distribution of the metal in the levers to avoid undue deflection which may cause either quickness or slowness of action; or may cause inaccuracy through change in the length of the lever arms.

e All knife edges should be in the same plane and each a true edge, hard and sharp; if the edges are not in the same plane, the bearings have a tendency to slide, producing a pressure against the lever on the low side of the knife edge, causing friction and sluggishness of action.

f There must be provision for draining the pit thoroughly and keeping it dry, to prevent corrosion as much as possible, as well as for inspection. Knife edges are subject to corrosion and this drainage and inspection must be provided in order to insure the continued accuracy of the scale.

In the design of a scale the maximum load per truck must be considered, otherwise the levers and connections will be too light and mischievous deflection with possible failure occur. At the present time the largest axle used in freight service has the 6-in. by 11-in. journal with a capacity of 50,000 lb., or a maximum load of 100,000 lb. upon one truck (four wheels).

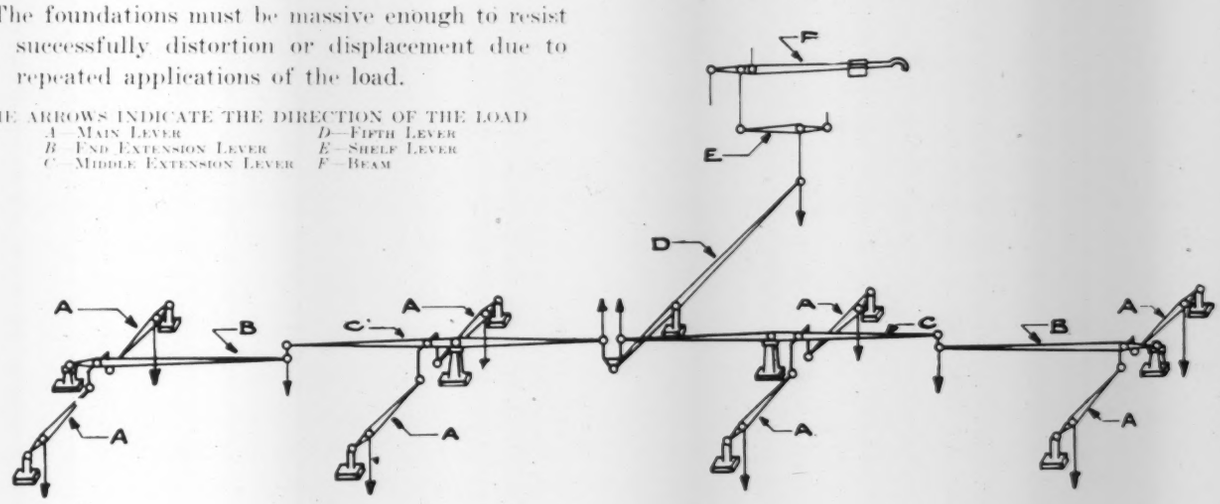

Fig. 1 Lever Diagram

Assuming a scale of four sections, of 150 tons total capacity, the usual allowance would be for a load of 37.5 tons at each section, plus a certain additional load due to the weight of the bridge and its dead load. On this basis, however, the levers and their connections would be too light, since with a load of 50 tons per truck moving across the platform, it is very evident that the stresses would mount higher than those for which allowance was made. By taking into consideration this maximum axle load, it is possible to have the main levers of all track scales made standard and with this standardization they become interchangeable and ready for immediate use.

The bridge may be built in one piece, or made in sections having a flexible connection, according to the length of the platform. For scales of large capacity,

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and considerable platform length, it is advisable to design a bridge for the largest possible load that may come upon it, making it in sections, the joints of which come over the main bearings. This obviates the objectionable pounding upon the knife edges, which occurs with a continuous beam, due to deflection, and there are other advantages, such as ease of handling, etc.

To relieve the knife edges of some of the hammering, which they are sure to get when the moving wheels roll from the solidly laid track to the live rails on the weigh bridge, it is customary to carry the bridge girders somewhat beyond the end of the platform. The most satisfactory plan would be to prolong the girders for the end span so that the load would be applied at their middle points. This, however, would have the objection that the pit and the bridge would be too long, entailing unnecessary expense. On examining several designs, no standard proportions were observed, the length of the extension varying from less than a fourth the length of the end span down to nothing.

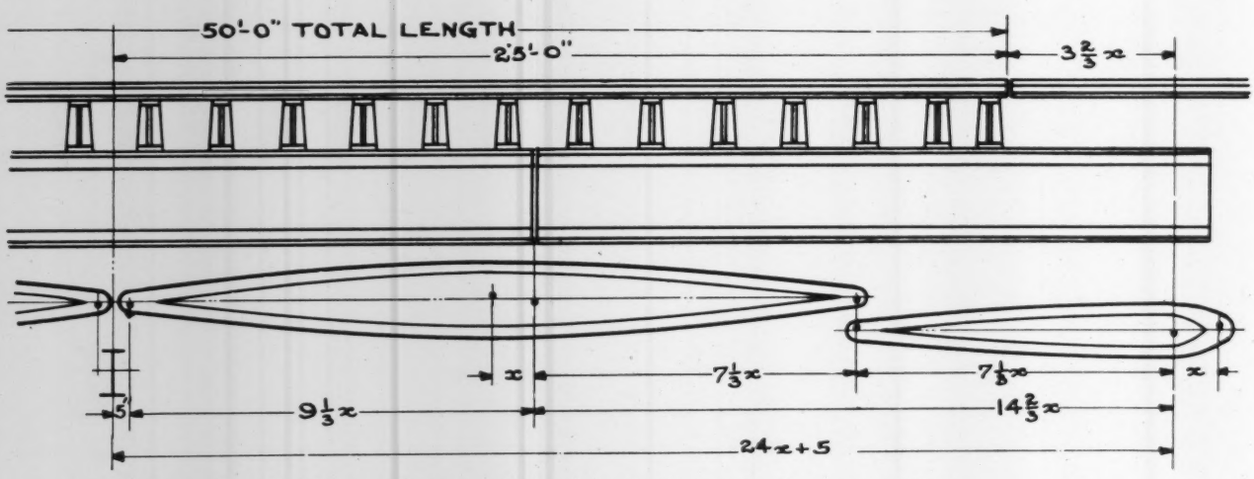


Fig. 2 Diagram Showing Dimensions of Platform, Girders and Levers

PROPORTIONS OF LEVERS

In Fig. 1 is shown a lever diagram and in Fig. 2 the platform arrangement and the proportions of the middle and end extension levers for a track scale. In this design it is assumed that the extension of the weigh bridge girders is ¼ of the length of the end spans.

Allowing 5 in. on each side of the transverse center line for the connections of the middle extension levers to the fifth lever, the necessary lengths of the weigh bridge girders, and the lengths of the end and middle extension levers may be found as follows, assuming the leverage ratios to be:

Main levers	3
Extension levers	$8\frac{1}{3}$
Fifth lever	8
Shelf lever	5

This makes the leverage ratios at the several connection points as follows:

At fifth lever	25
At shelf lever	200
At butt of beam	1000

The lever lengths in Fig. 2 are expressed in terms of the short arms, x, of the levers, designated as "fulcrum" lengths. One-half the platform length, which is considered in connection with the levers shown, is 25 ft. = 300 in.

The length from the transverse center line of the scale to the load knife edge on the end extension lever is $24x + 5$ in. and the weigh bridge girder extension is one-fourth of the end span, or $\frac{11}{3}x$. Then

$$300 \text{ in.} + 3\tfrac{2}{3}x = 24x + 5 \text{ in.}$$
$$x = 14\tfrac{5}{8} \text{ in. (approximately)}$$

which gives for the extension of the weigh bridge girders beyond the end of the platform

$$\frac{11}{3} \times \frac{117}{8} = 53\tfrac{5}{8} \text{ in., or 4 ft. } 5\tfrac{5}{8} \text{ in.}$$

The lengths of the levers will be

End extension, fulcrum $14\frac{5}{8}$ in., total length 10 ft. $1\frac{7}{8}$ in.

Middle extension, fulcrum $14\frac{5}{8}$ in., total length 20 ft. $3\frac{3}{4}$ in.

The best condition for the application of the load to the main levers will be when the load knife edge is directly under the center line of the rail. From center to center of rails is 4 ft. 11 in. Allowing $5\frac{1}{2}$ in. on each side of the center line of the lever, for the connections from the end of the main levers to the main, or load, knife edge on the extension levers, gives a lever 3 ft. long with a fulcrum of 12 in., the main lever ratio being 3.

BEARINGS AND KNIFE EDGES

Both the knife edges and the bearings against which they rest should be of high-grade tool steel, annealed, hardened and ground. Bearing surfaces must be generous and construction and materials of the best, other-

wise, the rough treatment administered to scales, such as the pounding due to the moving load and the tendency for the knife edges to corrode will lead to rapid deterioration. A load of 5000 lb. per linear inch of knife edge may safely be allowed, but this should not be exceeded.

The knife edges are of square, or flat, steel forged to a taper of not more than $\frac{1}{4}$ in. to one foot. If a smooth forging is made, very little, if any, finishing is required. After thoroughly annealing and hardening, the bearing edge is made true and keen by grinding and polishing, care being taken to have the faces of the bearing edge at an angle of not less than 90 deg. This edge must be straight in order to provide a full bearing along its length.

To insure a firm bearing in the levers, the knife edge seats are made in two ways. By skillful founding, the roughed forged knife edges are cast into the lever in their proper positions, and driven out for finishing, after the lever casting has cooled. This method is cheap, but it offers opportunity for misalignment. The preferable method is to broach, or slot, the seats, thus assuring accurate spacing and alignment, besides making the knife edges interchangeable. The knife edges should have sufficient metal backing to keep the unit bearing stresses low and prevent bending.

The design of the bearings against which the knife edges rest will differ according to the capacity of the scale. For the smaller capacities a direct and more or less non-adjustable bearing may be used; but where the capacity is large, a suspended, adjustable bearing is not only desirable, but necessary.

The bearings should be more or less self-aligning, vertical adjustment being provided by wedges over the main bearing, which have screw adjustment. The wedges are held securely in position by bolts which are drawn down after adjustment has been made.

The present practice for the bearings is to use an insert of steel, usually set in the mold before the casting is poured, as in the case of the knife edges, although interchangeability and accuracy can be more readily attained by machining the recess for the seat. Hardening is readily accomplished by withdrawing the steel insert from the casting. A true surface is obtained by grinding and polishing the steel while it is in the casting, care being taken not to draw the temper in the operation.

In the track scale, the dimensions of which are given in this paper, the approximate load upon the main knife edge of the main lever is 64,000 lb., which requires a length of knife edge of approximately 14 in. in order to keep the load below the specified 5000 lb. per linear inch. The butt knife edge will be 10 in. long, while the tip edge will be 5 in. long. The end extension lever will have the following knife edge lengths: butt 9 in., main 10 in., tip $1\frac{1}{4}$ in. The middle extension will be as follows: tip $1\frac{1}{4}$ in., main edge 5 in., bearing edge 9 in., and the tip nearest the fifth lever $2\frac{1}{2}$ in. The fifth lever will be as follows: butt 5 in., main $5\frac{1}{2}$ in., tip 1 in. The shelf lever knife edges need not be considered, because the theoretical lengths will not correspond to the finished article.

LINKS, LOOPS, SHACKLES, ETC.

All links, loops, shackles, and similar details should be designed stiff enough to prevent stretching, with consequent binding, which hinders ease of working. If the knife edge loops are not stiff enough, the load has a tendency to straighten the arch, which throws the load upon the knife edge at a point farthest from the support; the load being concentrated, produces excessive bending stresses, either bending the knife edge or snapping it (Figs. 3 and 4). Where knife edges are not reinforced, this bending must be considered, in

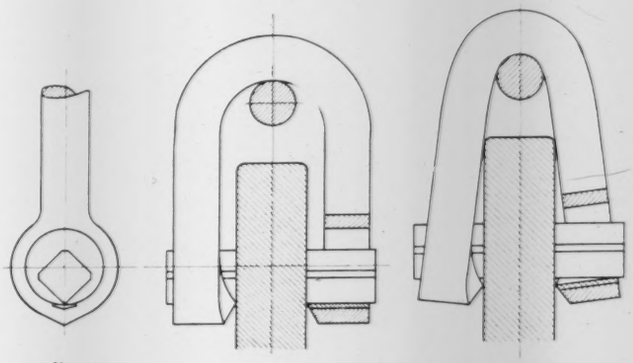


Fig. 3 Fig. 4

Fig. 3 Knife Edge Loop under Normal Conditions
Fig. 4 Knife Edge Loop under Abnormal Conditions

spite of the fact that the loop is made stiff enough to prevent stretching. A formula which seems to give satisfaction, is

$$P = 0.4\ Sd^2.$$

in which

P = safe working load, in pounds.
S = stress, per square inch.
d = diameter of iron, in inches.

It is advisable to use a good quality of wrought iron in preference to steel. Steel has a tendency to break without giving previous warning, while wrought iron will bend before breaking.

LEVER SECTIONS

The sections of the levers will next be investigated. It is necessary to consider stiffness more than strength. Too often a lever which is sufficiently strong from the standpoint of strength will deflect under load a noticeable amount, causing the ratio of the lever arms to change, giving inaccurate readings on the beam.

The main levers are to be steel castings, while the extension and fifth levers are to be made of structural shapes. The shelf lever may be either a forging or a casting. The beam is usually a casting, although foreign manufacturers do not hesitate to make it from a

forging. Since the levers are to be of steel, the allowable stress under repeated application of the load will be assumed to be 5000 lb. per square inch.

The maximum moment for the main lever will be about 600,000 lb.-in., requiring a section modulus of 120 (in.)^3. An I section 12 in. wide by 12 in. deep, having flanges and web 1 in. thick, will give a section modulus of about 135.3 (in.)^3, which is sufficient for all practical purposes. All knife edges are to be reinforced to prevent bending while under load. The depth of the lever will vary, tapering from the point of maximum bending moment toward the tip and butt, and the width of the flanges will decrease toward each

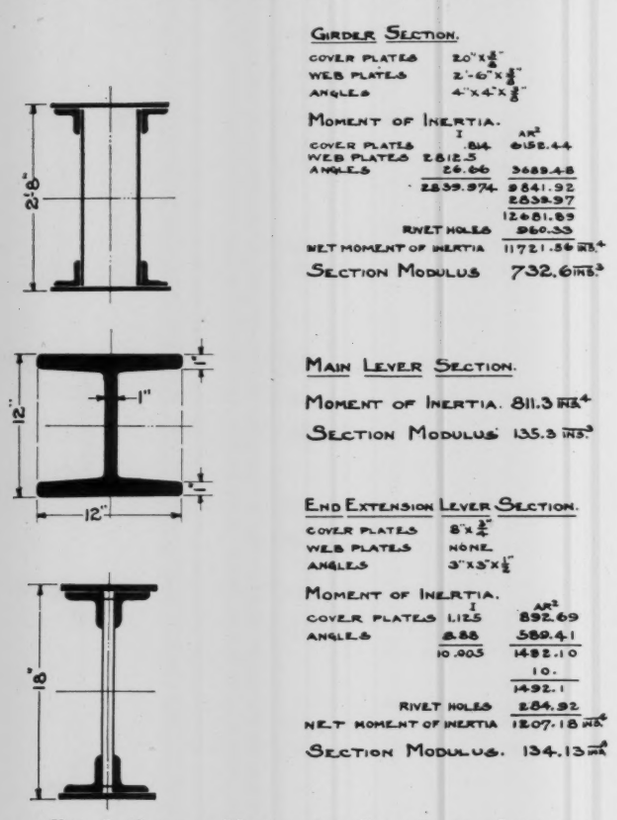


FIG. 5 SECTION MODULI FOR GIRDERS AND LEVERS

end. The thickness of the flanges and web will be uniform throughout.

The maximum bending moment for the end extension lever will be 643,500 lb.-in., which requires a section modulus of 128.7 (in.)^3. A latticed section made up of cover plates 8 in. by 3/4 in. and 3-in. by 3-in. by 1/2-in. connection angles, gives a net section modulus of 134.13 (in.)^3, for a section 18 in. deep, due allowance having been made for $^{13}/_{16}$-in. rivet holes.

The maximum bending moment for the fifth lever tension lever will be 1,452,500 lb.-in., which requires a section modulus of 290.5 (in.)^3. A section 26 in. deep, composed of 8-in. by 3/4-in. cover plates and 3-in. by 3-in. by 1/2-in. angles, will give a section modulus of 306.11 (in.)^3 net, deduction for $^{13}/_{16}$-in. rivet holes having been made.

The maximum bending movement for the fifth lever will be 456,000 lb.-in., which will require a section modulus of 91.2 (in.)^3. A section 15 in. deep, composed of 8-in. by 3/4-in. cover plates and 3-in. by 3-in. by 1/2-in. angles, will give a section modulus of 106.64 (in.)^3 net, deduction having been made for $^{13}/_{16}$-in. rivet holes.

The maximum moment of the shelf lever will be 28,800 lb.-in., which will require a section modulus of 5.76 (in.)^3. A section 1 in. wide by 6 in. deep, will give a section modulus, gross, of 6 (in.)^3, or about 5.84 (in.)^3, when deduction for the knife edge hole has been made. This lever has a fulcrum of 12 in. and a length of 5 ft., its ratio being 5.

In all these computations, the dead load of the weigh bridge has been carried, a larger value than necessary having been chosen in order to be on the side of safety.

Range on each lever must be provided in order to compensate for unequal distribution of the metal about the knife edge line and any deflection that may occur. This range is accomplished by raising the main knife edge above a line through the tip and butt knife edges by an amount equal to 1/8 in. per foot of fulcrum (see Fig. 7).

The main lever main knife edge will be allowed a range of 1/8 in., as will also the extension levers, while the fifth lever will have a range of $^3/_{16}$ in.; the shelf lever will be given a range of 1/8 in., while the range on the beam is almost negligible, less than $^1/_{16}$ in., yet it must be considered.

A resumé of levers will be useful (see Figs. 5 and 6):

LEVER	M MAX.	SEC. MOD.	SECTION
Main	600,000	135.3	Cast steel I
End extension	643,500	134.13	2-8 in. by 3/4 in. pl, 4-3 in. by 3 in. by 1/2 in. Ls—18 in. deep
Middle extension	452,500	306.11	4-8 in. by 3/4 in. pl, 4-3 in. by 3 in. by 1/2 in. Ls—26 in. deep
Fifth	456,000	106.4	2-8 in. by 3/4 in. pl, 4-3 in. by 3 in. by 1/2 in. Ls—15 in. deep
Shelf	28,800	5.84	6 in. by 1 in. steel or W. I.
Beam	3,000	1.00	3 in. by 3/4 in. steel or W. I

GIRDERS

The middle span of the weigh bridge will be subjected to a live load of 100,000 lb. passing over it; the end spans, particularly the one at entrance, will be subjected to impact, due to the moving load dropping from the dead rails to the live rails on the weigh bridge, or the wheel striking the end of the rail, due to a difference in level, or a gap, between rail ends. While a condition of unequal levels is not desirable, yet, wear, settlement, along with frequent repairs, cause inequalities in alignment.

As noted before, there will be an objectionable pounding upon the knife edges if a continuous girder is used, due to the deflection of the weigh bridge upon application of the load, so the bridge will be subdivided into three parts, the joints coming over the main bearing stands of the main levers; each girder will be made stiff enough to resist deflection due to the applied load.

The greatest bending comes upon the middle span;

for uniformity and quickness in assembling, the girder sections for end spans will be the same as for the middle span.

The girders should be designed for stiffness, so a permissible deflection of $^3/_{32}$ in. will be assumed. The deflection formula for a beam supported at the ends and loaded at the middle is

$$\varepsilon = \frac{1}{48}\,\frac{PL^3}{EI} = 0.02083\,\frac{PL^3}{EI}$$

$$I = 0.02083\,\frac{PL^3}{E\,\varepsilon}$$

Using a modulus of elasticity of 25,000,000 lb. per sq. in. and limiting the deflection to $^3/_{32}$ in., we have

$$I = 0.02083 \times \frac{50{,}000 \times (283)^3}{25{,}000{,}000 \times \frac{3}{32}}$$

$$= 10{,}080\ (\text{in.})^4$$

It will be interesting to compare this result with what would have been obtained if the fundamental formula for bending had been used, with the stress due to suddenly applied loads.

From tests on the fatigue of steel under repeated loading, by Wöhler and Spangenburg, and the later tests by Bauschinger and at the Watertown Arsenal, the following formula may be used in finding the proper safety factor to be used for variable loading of an indefinite number of repetitions:

$$F_2 = \left(2 - \frac{P_2}{P_1}\right) F_1$$

in which

F_1 = safety factor under static loading.

F_2 = corresponding safety factor under a loading that varies, repeatedly, between the limits P_1 and P_2.

P_1 = greatest pressure due to the variable load, to be taken as plus (+) if causing tension and minus (—) if causing compression, in the most strained fiber of the member.

P_2 = least pressure due to the variable load, to be taken as plus (+) if causing tension and minus (—) if causing compression, in the most strained fiber of the member.

This formula is applicable to the case of steadily applied loads as well as to the cases in which the load varies from O to P_1, and P_2 to P.

Since, for any given material, the working fiber stresses for the different conditions of variable loading are inversely proportional to the corresponding safety factors, it is apparent that the formula may be put in the following form:

$$f_2 = \frac{f_1}{2 - \frac{P_2}{P_1}}$$

in which f_1 = working fiber stress, under static loading, in pounds per square inch.

f_2 = corresponding working fiber stress under a load that varies repeatedly between the limits P_1 and P_2, in pounds per square inch.

P_1 and P_2 have the same signification as noted before.

For the case where the load varies from O to P_1, the formula becomes

$$F_2 = \left(2 - \frac{O}{P_1}\right) F_1 = (2 - O)\,F_1 = 2\,F_1$$

or

$$f_2 = \frac{f_1}{2 - \frac{O}{P_1}} = \frac{f_1}{2}$$

which indicates, for a suddenly applied load, indefinitely repeated, that the safety factor should be twice that for static loads, under otherwise similar conditions.

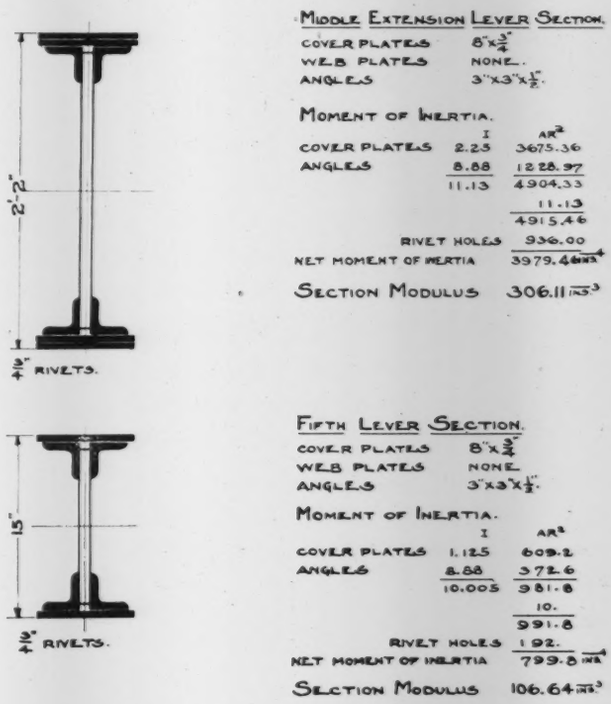


FIG. 6 SECTION MODULI FOR LEVERS

The maximum bending moment for the end spans will be

$$\frac{50{,}000 \times 214.5}{4} = 2{,}681{,}250 \text{ lb.-in.}$$

The maximum bending moment for the middle span will be

$$\frac{50{,}000 \times 283}{4} = 3{,}537{,}500 \text{ lb.-in}$$

The customary stress for bridges, subjected to live loads, is about 12,000 lb. per sq. in. The formula developed indicates that half this stress should be allowed; so, using a stress of 6000 lb. per sq. in., we have a section modulus of

$$\frac{I}{c} = \frac{M}{S} = \frac{3{,}537{,}500}{6000} = 589.6 \text{ (in.)}^3$$

against a section modulus of 630 (in)^3 (considering a section 32 in. deep) derived by the flexure formula. Only too often, girders are designed without due regard to stiffness, or the effect of loads suddenly applied, with very apparent deflection when loaded.

Using a section 32 in. deep, composed of two 20-in. by ⅝-in. cover plates, two 30-in. by ⅝-in. web plates and four 4-in. by 4-in. by ⅝-in. angles, and deducting for $^{13}/_{16}$-in. rivet holes, we have a net moment of inertia of 11,721.56 (in.)^4, which gives a section modulus of 732.6 (in.)^3, well within what is required.

To prevent buckling of the web, reinforcing angles are spaced at intervals along the girder. Over the supports, sufficient angles must be used to carry the load, considering the angles as a column. Gordon's formula for columns with square bearings is:

$$P = \frac{a}{f}\left[\frac{50{,}000}{1 + \frac{1}{36{,}000}\left(\frac{12\,L}{r}\right)^2}\right]$$

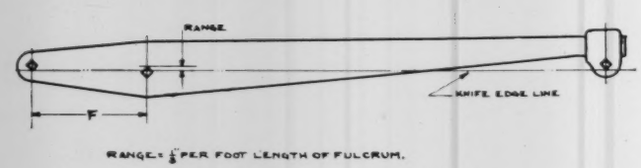


FIG. 7 RANGE IN LEVERS

in which

P = load to be supported, in pounds.
a = sectional area of column, in square inches.
f = safety factor.
L = unsupported length of column, in feet.
r = least radius of gyration, in inches.

The load to be supported is 50,000 lb. plus about 20,000 lb. for the weigh bridge. Using two angles in each column, each angle can be assumed to carry a half of the imposed load, or 35,000 lb. The formula then reduces to

$$35{,}000 = \frac{a}{8}\left[\frac{50{,}000}{1 + \frac{1}{36{,}000}\left(\frac{29\frac{1}{2}}{r}\right)^2}\right]$$

$$280{,}000 = a\left[\frac{50{,}000}{\frac{r^2 + 0.024}{r^2}}\right]$$

$$28r^2 + 0.677 = 5ar^2$$

But

$$I = ar^2$$
$$I = 5.6r^2 + 0.135$$

Using a 4-in. by 4-in. by ⅝-in. angle with a moment of inertia of 6.66 (in.)^4 the resulting radius of gyration is 1.067 (in.), while that from the table is 1.20 (in.). The area deducted for rivet holes will be more than made up by the 4-in. by ⅝-in. fillers which are necessary. Judicious spacing of 4-in. by 4-in. by ⅝-in. angles will go a long way toward stiffening the web and preventing it from buckling.

To prevent the girders from becoming displaced, and to hold them in proper alignment, each end of the middle section should be extended in such a way that the extension will telescope into the end of the end girders; and a tie plate should be riveted to the bottom plates of the girders, at the joint, in order to make a rigid connection horizontally and yet allow each girder to deflect, independently, vertically. In this way, freedom of movement for deflection is obtained, and the objectionable bending over the supports, which occurs in continuous beams, is eliminated. With each span deflecting with freedom, there will be no lifting from, or dropping upon, the knife edges, as the load passes from one span to the other.

THE BEAM

The beam is to be of the full capacity type, the main bar being graduated in thousands of pounds, and the fractional bar in hundreds of pounds, to a thousand, by tens. Assuming an index of graduation of 5 to the inch for the main bar, a run of 5 ft. will include a capacity of 300,000 lb., while an index of 10 to the inch for the fractional bar will give a run of 10 in.

With a fulcrum distance of 5 in. on the beam, the main poise will weigh

$$W = \frac{C\,F}{R\,M} = \frac{300{,}000 \times 5}{60 \times 1000} = 25 \text{ lb.}$$

and the fractional poise will weigh

$$W = \frac{1000 \times 5}{10 \times 1000} = \tfrac{1}{2} \text{ lb. or 8 oz.}$$

where

W = weight of poise in pounds or kilograms
C = capacity of scale in pounds or kilograms
F = fulcrum distance of beam, inches or centimeters
R = run of poise, inches or centimeters
M = ratio at butt of beam

If the beam is cocked, that is, flies all the way up or all the way down, and indicates a true balance only when the load indicated on the beam is exactly that on the platform there may be two faults: either too much weight above the knife edge line, or too much range.

Obviously, if there is too much metal above the knife edge line, the remedy lies in placing sufficient below to counteract its influence. In order to correct such troubles readily and avoid the useless addition of metal, it is usual to arrange the balance ball so that it can be placed in a position to correct this fault. The difficulty, due to too much range, is eliminated by reducing the range until it has disappeared. Slowness of action is very often caused by dull knife edges, unnecessary friction, too much metal below the knife edge line, or no range; eliminate the cause and the effect produced will disappear.

Since the beam has a fulcrum distance of 5 in., the total pull on the butt of the beam will amount to 600 lb., which gives a maximum moment of 3000 lb.-in., requiring a section modulus of 0.6 (in.)^3, which is satisfied by a section $\frac{3}{4}$ in. wide by 3 in. deep, deduction having been made for the knife edge hole. The trig loop is placed at the tip of the beam and the precaution to have the trigger down whenever a load is entering upon the live rails will save the beam many hard jolts and prolong its accuracy.

More details of the beam will be useful. For rapidity of weighing the fractional poise will be mounted upon the main poise so that the latter will include the weight of the fractional poise, its beam, and any other details that may be necessary.

The main beam will be notched for each thousand pounds, and each notch accurately sealed, indexed and marked. The index and marking should be cut quite deep, because the service which most scales undergo is not of the best and seldom is much attention given to polishing and cleaning the beam or otherwise keeping it in order. The fractional beam will not be notched, due to inconvenience where quick weighing is desired.

The knife edges should be of square steel, the bearing edge being ground and polished to a true edge, which must be hard and sharp, clean at all times, to assure accurate and sensitive weighing.

Projections upon the beam, or poises, are not desirable. Dirt rapidly accumulates and destroys the accuracy of the scale. Likewise, openings of any kind offer opportunity for dirt to accumulate or weight to be surreptitiously extracted from the poise. In other words, anything that can be conscientiously done to promote accuracy in weighing must be done; it is preferable to leave no detail incomplete.

The beam stand must be built solid enough to withstand the shock of the suddenly-applied load. From the point of safety it is desirable to keep the beam as far as possible from the track, but too great a distance means a long lever, which is objectionable, due to the increased depth necessary to get the requisite strength and the consequent increase in weight. Cars average close to 10 ft. in width at the eaves; whether this width may be exceeded or not is due to clearance limitations on certain roads; at any rate, future expansion must be provided for. Allowing five feet between the side of the car and the building and about four feet from the outside of the wall to the reach rod from the tip of the fifth lever to the shelf lever, we have a fifth lever of 14 ft. 3 in. long, a ratio of 8 giving a fulcrum distance of 19 in. and a long arm of 12 ft. 8 in., this lever being of the first class.

PLATFORM, BRIDGE AND RAILS

A platform of such great size and weight as required for this scale should have ample clearance and be entirely free of any movement of the weigh bridge to prevent binding at any point due to the accumulation of dust and dirt. To provide proper clearance the pit will be made 10 ft. wide. To support the platform I-beams spaced at proper intervals will be used. The greatest load that can come upon one I-beam will be the load upon one axle and the maximum moment will be when the wheels just straddle the center line of the scale; this moment will be about 825,000 lb.-in., a 15-in.-42-lb. I-beam being sufficient.

To make the platform durable concrete should be used. With this construction repairs are infrequent and not very costly; a tight cover for the pit is assured.

The bridge, through its bearings, rests freely upon the main lever knife edges, there being no rigid connection between them. To prevent the bridge from sliding, a system of lateral and longitudinal checks is provided. These checks should be made as long as possible in order to prevent binding when the bridge deflects, while under load; the theory is, the longer the check, the more nearly the short path described approaches a straight line.

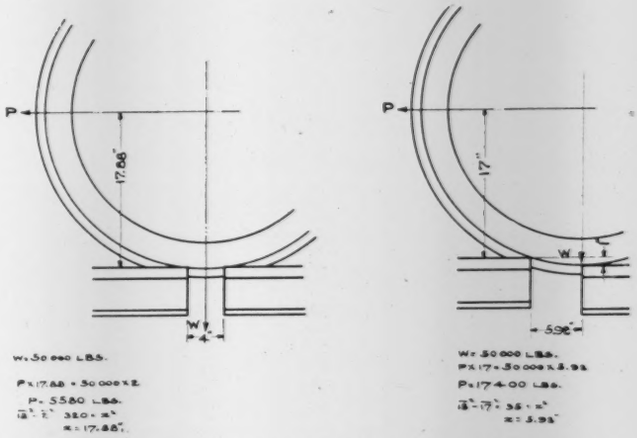


Fig. 8. Diagram showing Rail Conditions at Entrance

The load applied to the checks is caused in several ways, any one of which may occur. The end of the live rail may be some inches from the solidly laid dead rail, so that a blow is administered to the end of the live rail as the wheels enter upon it. Another condition is due to adhesion, or friction, between the wheels and rails when the brakes are applied. Still another condition, similar to the first, is a difference in the level of the live and dead rails, the worst blow coming when the live rail is above the dead rail. Probably the worst situation is when the first two, or last two, occur at the same time. This will come about when three pairs of wheels are on the live rails, the fourth pair just entering, all brakes set and the last pair striking the ends of the live rails. The conditions brought about by rail inequalities are indicated in Fig. 8.

The pressure, due to the friction between the wheels and rails, when the car is suddenly stopped, depends upon the speed of the car. Assuming a speed of 5 miles per hour, the thrust will be

$$P = \frac{W}{g}\frac{V}{T}$$

The coefficient of adhesion for dry sanded rails is 0.25, so

$$P = \frac{50{,}000 \times 0.25}{32} \times \frac{5 \times 5280}{60 \times 60} = 2865 \text{ lb.}$$

This value is for one pair of wheels; for three pairs, the result will be 8595 lb., which is the thrust delivered to two longitudinal checks, or a thrust of 4297 lb. to each one.

Assuming a gap of 4 in. between rail ends, and a 36-in. wheel, the force of the blow will be

$$P = \frac{2 \times 50{,}000}{17.88} = 5580 \text{ lb.}$$

delivered to the two longitudinal checks, or a thrust of 2790 lb. to each check. If there is a difference in level of 1 in., the blow would be very much aggravated, as is indicated below.

$$P = \frac{50{,}000 \times 5.92}{17 \text{ in.}} = 17{,}400 \text{ lb.}$$

delivered to both longitudinal checks, or 8700 lb. to each check.

The total highest thrust will be due to the sudden stopping of the car on the live rails and the wheel striking the end of the rail when the live rail is higher than the dead rail, which amounts to 13,000 lb. Using a stress of 7500 lb. per sq. in., a round bar $1\frac{1}{2}$-in. diameter will be sufficient. In order to provide adjustment, the check will be provided with a turnbuckle; accordingly, the end of the bar will be upset for a $1\frac{3}{4}$-in. thread.

The lateral checks serve to prevent side motion, so for the sake of uniformity, they will be made of the same stock as the longitudinal checks. In order to prevent binding, the checks should fit the check pins with freedom, and sufficient slack provided to allow, say, $^1/_{16}$-in. movement—just enough to allow the checks to be free when there is no load upon the scale.

The rails are carried upon stands which are fastened to the bridge girders. These stands must be rigidly fastened to the girder and able to withstand much abuse, due to derailments. To hold the rail firmly, suitable clamps must be used, which have not the bad habit of working loose in service.

A dead rail has not been considered, it being preferable to provide a relief mechanism, or pass cars and locomotive around the scale on another track. Dead rails offer too much temptation to an engineer to use the live rails for shifting, etc., as is very often done.

The high axle loads of the locomotives now in use are often beyond the capacity of the scale and such excessive loads must not be allowed to pass over the weigh bridge.

While the scale is designed to withstand considerable misuse and much neglect, yet this provision does not mean that the abuse may be continued with entire safety. The metal will fatigue, eventually, and possible costly repairs result. When the design of a track scale is considered, it must be borne in mind that stiffness in construction, coupled with lightness of moving parts and absence of friction, is to be desired.

Upon the sealer depends the accuracy and dependability of the weights indicated. Inspection should be frequent and thorough in order to detect and repair any damage that may have occurred through age or abuse. It is always preferable to have sufficient foresight to prepare for an emergency and, if possible, prevent a breakdown which may cause serious trouble.

Too much stress cannot be laid upon the honest and conscientious performance of the responsibility laid upon the weigh master. The public no longer tolerates tampering with weights; they have demanded honesty and show their earnestness of purpose by the many legal enactments and the frequent prosecution of offenders.

NECROLOGY

MAX JULIUS ULRICH

Max Julius Ulrich, designer in the oil engine department of the De La Vergne Machine Company, died July 27, 1914, after a three days' illness.

Mr. Ulrich was born at Halle, Germany, February 8, 1856. He was educated at the Royal Technical Institute at Halle and graduated from the Polytechnic Institute at Karlsruhe. He served an apprenticeship to Emil Stahrer at Leipzig from 1870 to 1873, and from 1873 to 1874 was spent in the drawing room of W. Uhland at Leipzig. He later spent a year in shop experience with Sachsenberg Brothers, Rosslau, in building mining machinery, and from 1879 to 1881 was designer for Messrs. Haddick & Roethe, pump-builders at Weissenfels, Germany.

After this, he came to the United States, and in 1882 became superintendent and mechanical engineer of the Ulrich Engine Company of Florence, Massachusetts, where he remained until 1894. During this time he invented a cut-off motion for duplex steam pumps which was patented in the United States, England and Germany. From 1892 to 1894, he served also as designer for the Deane Steam Pump Company, at Holyoke, Massachusetts. In 1894, he became chief draftsman of the Deane Company and held this position, with the exception of three years' absence, until 1901. During the period from 1900 to 1902, he also wrote two courses for the International Correspondence Schools in hydraulics and pumping machinery design.

In 1902 he came to New York as chief draftsman for the Alberger Condenser Company, which position he retained until 1912. His first undertaking here was the designing of the condensers installed in the 59th Street power station of the New York Subway, by the Alberger Company.

On December 15, 1912, he became designer in the oil engine department of the De La Vergne Machine Company, and held this position at the time of his death.

Mr. Ulrich was a member of the Verein deutscher Ingenieure and was a prominent Mason.

SYMPOSIUM ON POWDERED FUEL

At the Spring Meeting, June, 1914, one Session was devoted to a Symposium on Pulverized Fuel at which three papers were presented upon different types of plants using pulverized fuel apparatus as follows: Pulverized Coal Burning in the Cement Industry, R. C. Carpenter, Pulverized Coal for Steam Making, F. R. Low, and An Installation for Powdered Coal Fuel in Industrial Furnaces, Wm. Dalton and W. S. Quigley. There was also a topical discussion upon the constructive and operative features of pulverized fuel plants.

PULVERIZED COAL BURNING IN THE CEMENT INDUSTRY

BY R. C. CARPENTER, ITHACA, N. Y.

Member of the Society

The process of burning powdered coal has been developed in but few arts and only in relation to certain types of furnaces. For more than 30 years various schemes for burning powdered coal in boiler furnaces have been suggested and numerous patents have been taken out on various processes and burners, but without any marked degree of success. In the Portland cement industry commercial success was attained more than 15 years ago as a result of a series of investigations and experiments. The furnace employed had much to do with the practical success which was finally attained, and for that reason its construction and mode of operation will be briefly described. This furnace is familiar to Portland cement engineers, but is not well known in the other arts.

Portland cement is manufactured from a mixture of materials containing lime and silica which are brought together in definite proportions to produce a chemical combination. The raw material is principally carbonate of lime, or limestone in some form, and clay or shale. The materials are pulverized raw and mixed in proper proportions. The raw mix is introduced into a kiln either in the form of a dry powder or in a wet and plastic condition where it is subjected to an extremely high temperature and in which the required chemical combinations take place. The material discharged from the kiln is known as cement clinker; it is pulverized in various forms of grinding mills and reduced to a powder so fine that 92 parts or more will pass through a sieve having 100 meshes to the linear inch. This paper has to do only with the combustion process which takes place in the kiln. In the early days of the art fixed kilns were employed, but at the present time the rotary kiln is almost universally used.

THE ROTARY KILN

The rotary kiln in its essential features was patented by Siemens in 1869 and, in combination with a gas burner and other appliances, by Ransome in 1885. It was not found successful in England for cement burning, but was adopted by the Atlas Company in America about 1890 and was improved and developed by that company and other American companies to such a degree that it practically replaced every other method of burning Portland cement.

The modern rotary cement kiln consists of a slightly inclined steel cylinder mounted on rollers and arranged so that it can be revolved. The upper end is connected to a stack or chimney for the escape of the discharge gases and is provided with means for supplying the raw cement material in the form of dust or slurry. At the lower end of the cylinder is a stationary hood which performs the function of affording a discharge opening for the burned material and which also acts as a support for the fuel supplying devices. The rotary cylinders are of various dimensions. The tendency has been continually to increase the size of the cylinder. Thus, for instance, in 1890 the rotary kilns were in some instances 4 ft. in external diameter and 40 ft. in length. From 1895 to 1902 the kiln dimensions were quite generally 6 ft. in diameter and 60 ft. long. At the present time kilns 10 ft. in diameter and 150 to 200 ft. long are common. The Atlas plant at Hudson is equipped with kilns 12 ft. in diameter and 232 ft. long. In most of the late installations the kilns are true cylinders having the same diameter at top and bottom, but in many plants kilns are to be found with the diameter at the top about one foot less than at the bottom, the two parts being connected by a tapered section.

The rotary kiln is lined throughout with a fire-brick lining, except in rare cases where a very wet slurry is employed, in which case the lining for a short distance from the upper end is omitted. The temperatures required in the combustion chamber for burning cement clinker are from 2800 to 3000 deg. fahr. To withstand the high temperature, a lining having high refractory qualities must be employed. It must also have the quality of withstanding decomposition by the chemical action taking place in the kiln. The problem of kiln linings is a very serious one since no lining has been found that will stand for a great length of time under the conditions of operation. The lower part especially has to be repaired frequently unless the conditions are unusually favorable. The kiln is operated so as to keep the lining coated with the cement mixture for the purpose of protection. The lining prob-

Presented at the Spring Meeting, at St. Paul-Minneapolis, 1914, of The American Society of Mechanical Engineers.

lem, except as it bears on the combustion of powdered fuel, has no place in this paper and will not be discussed further.

A diagram of a cement kiln in elevation and plan is shown in Fig. 1. This diagram shows the general features and the arrangement of the various operating parts with reference to each other. In the diagram the rotary kiln is shown at *C*, the flue for discharge gases at *B*, the supporting rolls at *DD*, the stationary hood at the lower end at *E*, the rotary clinker cooler at *G*, the clinker pit at *F*, the blower for supplying compressed air at *H*, the coal bin at *K*, the feeding injector for coal dust at *J*, the conveyor for delivering coal to the fuel tank at *L*, the dust bin for raw material at *A*, and the kiln stack at *S*. The hood *E* is usually mounted on rolls so as to be easily moved for repairing of the kiln. It is customary to supply a separate stack for each kiln, although in some cases one stack receives the discharge from two kilns. In a large installation it is customary also to supply the air for several burners with one blower. In the installation shown in Fig. 1 the blower draws in air which has been warmed by passing through a rotary clinker cooler.

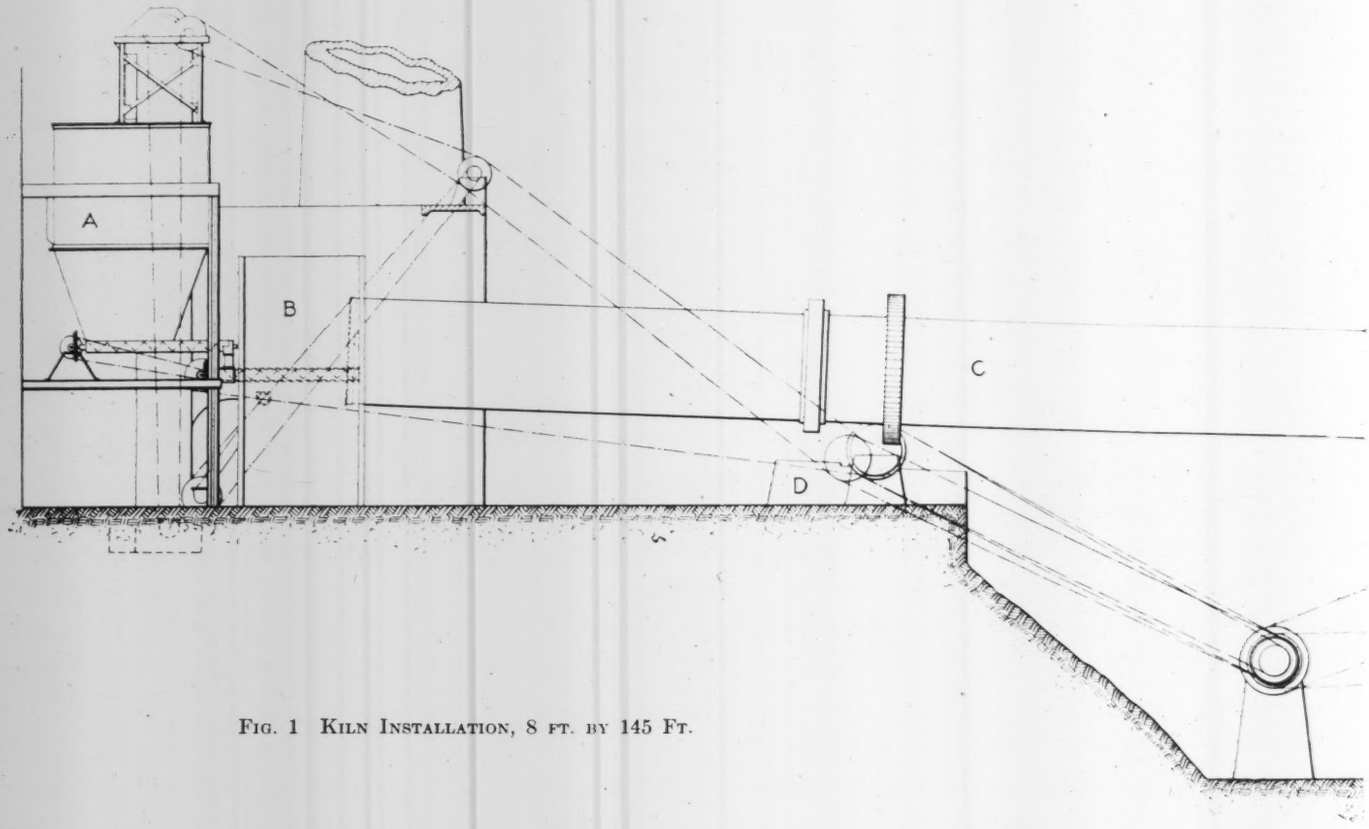


Fig. 1 Kiln Installation, 8 ft. by 145 Ft.

DEVELOPMENT OF THE BURNING PROCESS

During the early years of the Portland cement industry in this country, oil was employed as a fuel. This was sprayed into the lower end of the furnace with a jet of compressed air or steam. The oil was employed successfully, but due to the increasing cost after 1895 its use was very expensive. From 1897 to 1900, the increase in price was such as to make the use of oil nearly prohibitive from a commercial standpoint, and was the principal incentive for developing the use of pulverized coal.

In 1894, a series of experiments relating to the use of pulverized coal were started by the Atlas Company, in charge of Messrs. Hurry & Seaman, chief engineer and superintendent respectively. These experiments led to many discoveries, the invention of various parts, and finally to the commercial development of the art. Hurry & Seaman are entitled to the credit of the first successful use of powdered coal in the cement industry. This use was begun in 1895 by the Atlas Company and has never been discontinued. Other engineers along independent lines worked out the problem a few years later although possibly receiving some assistance from information disseminated throughout the industry relating to the results obtained by Hurry & Seaman. It may be stated that at the particular date referred to, every mill in the industry jealously guarded every detail of manufacture as a valuable trade secret, consequently little or no direct information as to details of process or machinery employed was common in the different mills. The information which leaked out at that time respecting details of operation or machinery was generally inaccurate and based on speculation or rumors. The success of the process of burning pulver-

ized coal in the Atlas plant was not generally known in other mills until about 1900 when the process was put in successful operation in various plants by independent investigators.

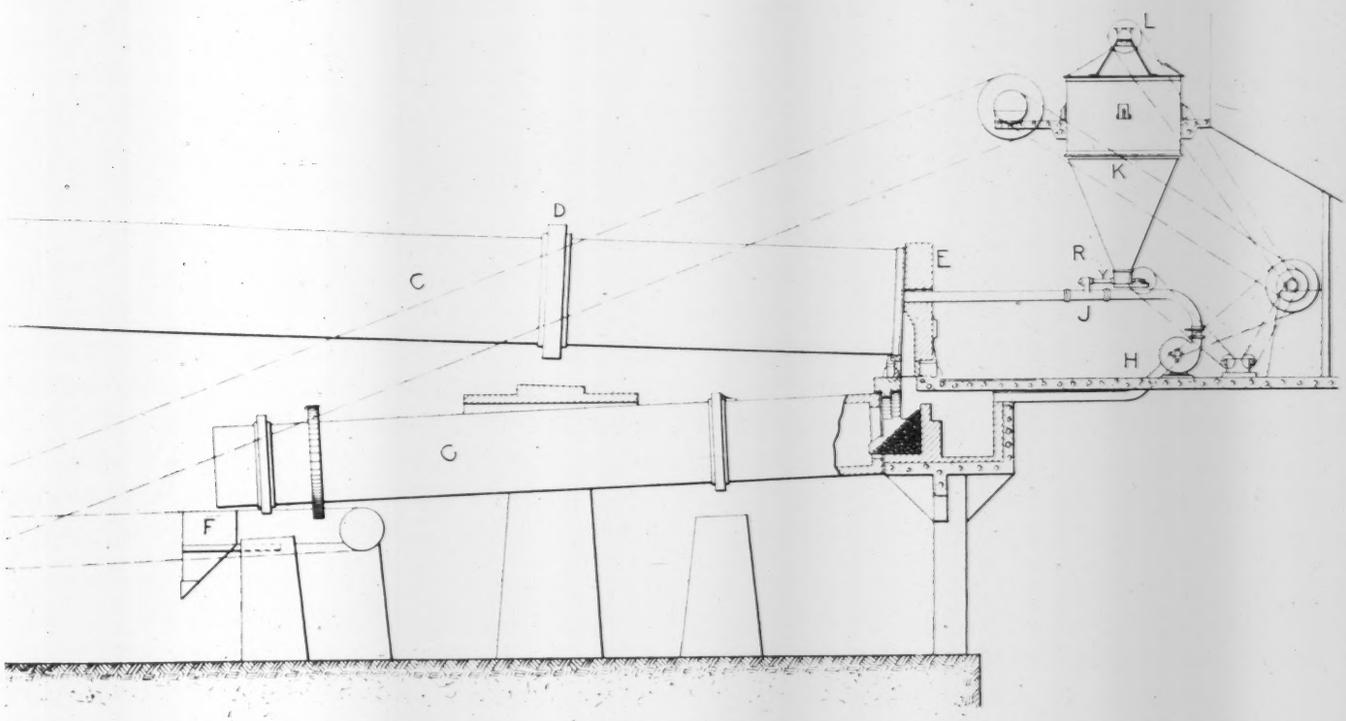
The art as at present developed consists of a process for delivering to the kiln the powdered fuel or fuel dust by a jet of air which impinges on the fuel dust in some type of injector with force enough to discharge the dust into the kiln. The process, with details of mechanism, is illustrated in Fig. 1 in relation to a kiln. Fig. 2 gives an idea of the character of the combustion which takes place in the burning of pulverized fuel.[1] The compressed air may be obtained from a fan or compressor as may be more convenient; the diagrams indicate both schemes.

The injector varies greatly in different constructions but it performs the function of injecting the coal dust into the kiln by a jet of air and it does not handle sufficient air for combustion. The additional air needed for combustion enters the kiln principally through openings in the hood and through the discharge duct for clinker. Such openings are shown in Fig. 2 by arrows at points marked *a*. The amount of air supplied by the compressors or fans should be sufficient merely to carry the dust into the kiln without producing an explosive mixture. The fuel dust enters the combustion chamber of the kiln in the form of a black cloud and burns in the form of an elongated torch, as indicated by Fig. 2. The length of the flame in actual kiln constructions is generally from 25 to 40 ft., although this is affected by conditions. The diameter of the flame in some places may very nearly equal that of the combustion chamber. Under best conditions of burning the flame does not perceptibly impinge against the sides of walls of the kiln, and the heat utilized is practically all given off by radiation.

THE POWDERED FUEL PROBLEM

The problem is one of combustion under peculiar conditions. The burning of pulverized coal differs from the burning of solid fuel, from a theoretical standpoint, principally in one particular. In the combustion of coal of commercial sizes lying on the grate, the air for combustion passes between the pieces of coal and the products of combustion pass off in the flues. Coal dust does not burn under such conditions, as the particles are so fine that sufficient air for combustion does not reach the coal through the crevices between the particles. To burn powdered coal successfully, it must be burned while in suspension in the air. In such a position each particle is surrounded by air which supports the combustion. The form of the furnace used in the Portland cement art is favorable for combustion in suspension since it is very long and affords plenty of room for such combustion.

Contact of the particles of coal dust with other bodies results generally in the lowering of temperature to such



[1] Supplied by Duncan & Duncan.

an extent as to make combustion impossible. The result is the virtual loss of any fuel which falls down onto the lining or onto the clinker. The time of combustion is evidently increased as the size of the dust particle is increased, from which it follows that the finer the grinding, everything else being equal, the quicker and more perfect the combustion.

In the early days of the development of the process of coal burning, ignorance of the necessity of fine grinding was the cause of many failures in burning coal dust. In the cement industry special devices for regulating the supply of air for injecting the fuel are supplied, but no special controlling apparatus is supplied for the air which enters the kiln through the various openings around the hood. It would be difficult indeed to control the admission of such air. By increasing the fuel charge, it is possible to bring the air supply down to nearly theoretical, or to any relative proportion desired. I have found from tests in the cement art that best results are obtained when there is a slight deficiency rather than an excess of air. This is denoted by a short carbon monoxide flame at the base of the stack and also by analysis of the escaping gases.

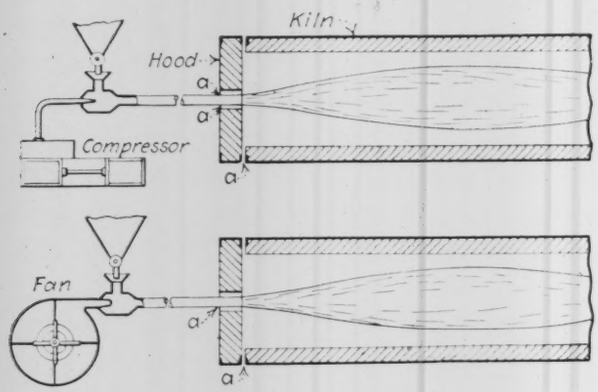


Fig. 2 Diagrams of Burner and Kiln for Powdered Fuel

Novelty of the process. Patents taken out many years ago for the burning of powdered coal under boilers and in various arts show various kinds of pulverizers and feeding devices, and also the idea of delivering powdered coal into the furnace by a jet of air or steam. Crampton suggested a pulverized coal flame for use in his type of rotary Portland cement furnace. No one, however, previous to Hurry & Seaman, seems to have comprehended the necessary underlying principle for successfully burning pulverized coal which requires the burning of the coal while in suspension and the utilization of the radiant heat of combustion without substantial impingement of the flame. The failure to recognize such requirements is, in my opinion, in a large measure responsible for the practical failure of the burning of pulverized fuel in boiler furnaces, although such furnaces, because of form and proportion, make difficult the problem of burning coal dust in suspension. In practically all of the devices which have been tried under boilers the coal dust has impigned on bridge wall or sides of the furnace or on portions of the boiler before the combustion could be completed, resulting in waste, lack of capacity, and destruction of fire-box and fire-brick linings and other portions on which the flame impinged.

FUEL

The fuel available for burning in Portland cement kilns can have a wide range of quality. The best bituminous coals are preferable, but those of quite poor quality are in successful use. I have known of the successful use of anthracite coal but it is difficult to pulverize and needs a high temperature for combustion.

The fuel used in the Eastern portions of the country is generally obtained in the bituminous mines of Pennsylvania, Maryland, Virginia or West Virginia. The coal employed in mills in the Western part of the country is frequently that most convenient to the plant and the cheapest in price on the heat unit basis.

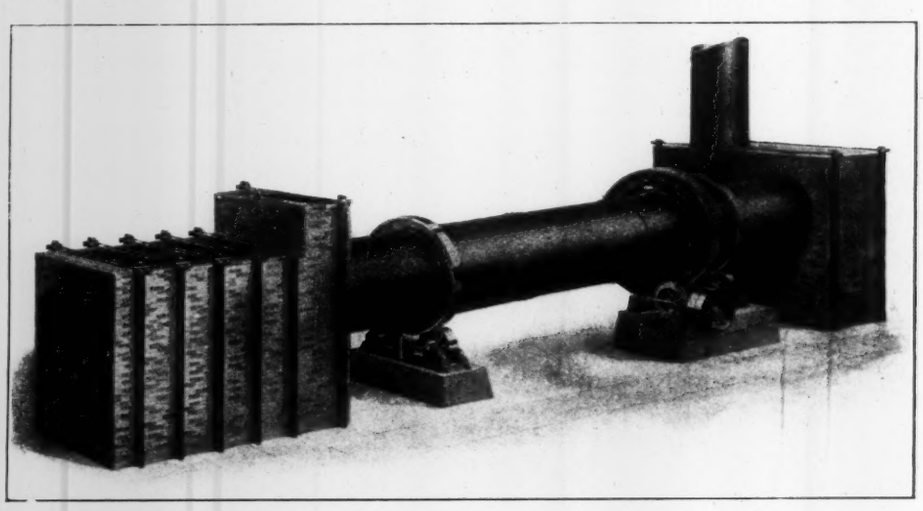


Fig. 3 General View of Rotary Dryer with Stationary Firebox

Before the coal can be ground it is necessary that it be dried so that the moisture content will be less than 1 per cent, as the water in coal seriously affects the operation of pulverizing. It also has a detrimental effect on feeding and on the capacity of the kiln. The effect of the moisture, however, depends upon the kind of coal, so that no limit can be definitely stated as essential to success in advance of a trial.

Capacity and Efficiency. The weight of pulverized coal required per barrel varies somewhat with the character of the kiln and the character of the process. In the dry process of manufacture the weight of fuel per barrel varies from about 22 to 26 per cent of the weight of cement produced, i.e., from 83 to 100 lb. of coal per bbl. In the wet process the coal varies from about 35 to 50 per cent of the finished product, i.e., from 133 to 190 lb. of coal per bbl. The theoretical amount of coal required, neglecting the heat due to the formation of silicates of lime and alumina, is probably not far from 30 lb. per bbl., provided 10,000 B.t.u. per lb. of coal is utilized. The continuous stationary kilns are reported as consuming 12 to 16 per cent of fuel or from 45 to 60 lb. per bbl. of cement.

The capacity, in barrels per 24 hours, of the modern kiln when operating on dry material with flue gases about 1000 deg. fahr., can be approximately expressed by the following formula

$$C = 0.1D^2L$$

where

C = capacity in 24 hours in bbl. of 380 lb.
D = outside diameter in ft.
L = length in ft.

The economy of the kiln has been increased by increasing its length, probably due in part to a change in the process of burning whereby the CO_2 is driven off from the material before it reaches the combustion zone in the kiln, and in part to a reduction in losses. The saving due to the use of the 150-ft. kiln in place of the 60-ft. kiln has exceeded 20 per cent in fuel and in addition has cut down the labor required in operation more than one-half. Kilns can be operated with a stack temperature less than 1000 deg. fahr, but in that event the capacity is lessened and the result is generally an increase rather than a decrease in cost.

Richard K. Meade, in his book on Portland cement, makes the following theoretical calculations as to the heat necessary per 100 lb. of raw material.

Heat required		B.t.u.	
Decomposition of 75 lb. $CaCO_3$ = 75 × 784 =		58,800	
Decomposition of 4 lb. $MgCO_3$ = 4 × 384 =		1,536	
			60,336
Heat supplied			
Burning of 0.3 lb. sulphur = 0.3 ×	4,050 =	1,215	
Burning of 0.8 lb. carbon = 0.8 ×	14,540 =	11,632	12,847
Balance to be supplied by fuel.....			47,489

About 600 lb. of raw material are needed per bbl. so that the total heat per barrel required would be 284,934 B.t.u., neglecting the effect of the silicates. The combination of the silicates and lime gives off heat. This amount is in doubt as the exact resulting composition of the silicates is not known. A certain combination might produce 44,700 B.t.u. per 100 lb. of raw material, which is hardly possible as it would reduce the theoretical heat to be supplied to 2789 B.t.u. per 100 lb. raw material, or to 16,734 B.t.u. per bbl. of cement.

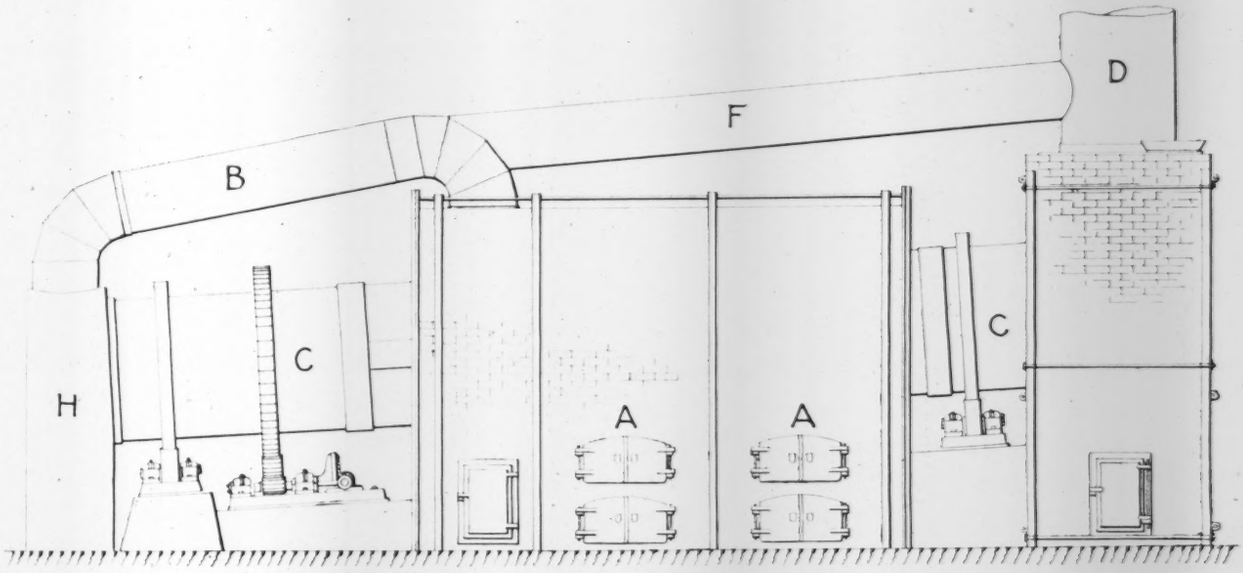


Fig. 4 Coal Dryer with Heated Gases passing through Cylinder

The principal cause of lack of economy in the rotary kiln appears to be due to excessive flue loss. Dr. Joseph W. Richards[1] has reported the following distribution of heat losses in a 6 x 60 kiln:

36 per cent excess air in chimney gases
36.1 per cent necessary products of combustion
10.7 per cent in hot clinker
12.8 per cent in radiation and convection

The above investigation indicates about 72 per cent flue loss of which about one-half is due to poor operation and is preventable.

In order to utilize the waste heat in the stack, I arranged in the Cayuga Lake plant to pass the discharge

[1] Engineering Record, Feb. 27, 1904.

gases of two kilns through a boiler and an economizer, the draft being maintained by a fan. I also arranged to heat the air entering the kilns by drawing it through the hot clinker discharged from the kilns. The kilns were 60 ft. in length and 7.5 ft. in diameter at the lower and 6.5 ft. at the upper end. A very complete test was made by J. W. Prince, M.E., under my general directions, of which the results are shown in Table 1.

From these data Table 2 has been computed showing the approximate distribution of heat throughout the process.

This investigation showed that about 50 per cent of the heat was discharged into the stack and of that amount about 68 per cent could be utilized in a boiler and economizer so that the ultimate flue loss was reduced to about 17 per cent of the fuel.

In the cement industry very few attempts have been made to utilize the heat of the escaping gases. So far as I know, the only successful installation of that kind is that in the plant at Kosmosdale, Kentucky. The reason why the waste heat has not been utilized to a greater extent is no doubt due to the difficulties of arranging and maintaining the waste heat boilers in good condition. I am satisfied, however, that such difficulties are not so serious as to prevent a good return on the investment. It is doubtful if the difficulties are more serious than have been overcome in the steel industry.

Since 1902 the present methods of burning Portland cement have been in successful use, and without further reference to prior methods I will give a brief description of the machines employed, without going into minute details, so that they can be made a permanent part of the records of the Society. The operations required for burning pulverized coal consist in (*a*) drying, (*b*) pulverizing, (*c*) conveying, (*d*) storage, and (*e*) feeding. All these operations are provided with special machines and will be discussed later in the paper.

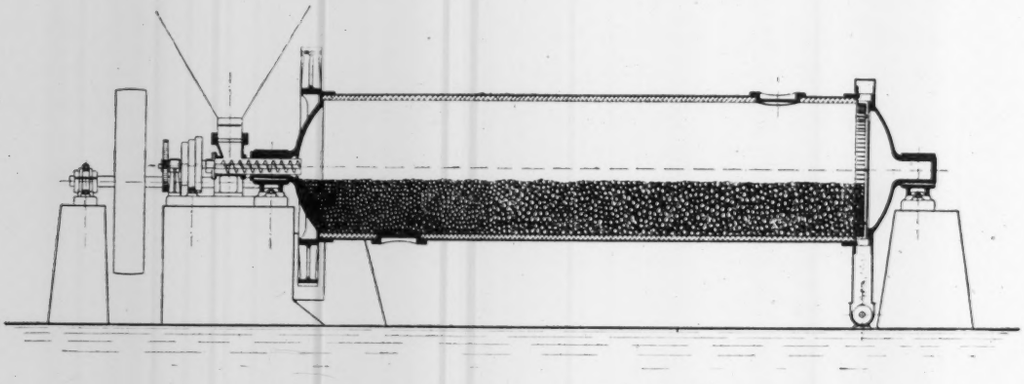


Fig. 5 Section of Tube Mill

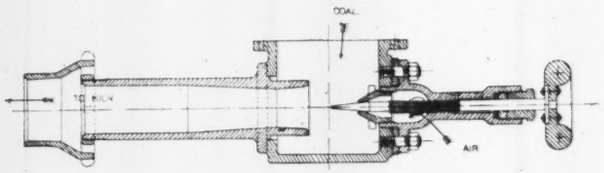


Fig. 6 Sectional View of Atlas Burner

TABLE 1 DATA TWO KILNS, EACH 7½ AND 6½ x 60

Coal consumed per hour, lb.	1888
Clinker specific heat,	0.2
Clinker produced per hour ($CaO = 62$ per cent), lb.	8018
Weight $CaCO_3$ per hour, computed, lb.	8875
Moisture in raw material, per cent	3.1
Weight CO_2 per hour from material, lb.	3660
Weight of air supplied per lb. of coal, 44 per cent excess, lb.	16.1
Total weight of air supplied per hour, lb.	32397
Weight of air supplied by coal feeders per hour, lb.	5850
Total weight of gases discharged per hour, lb.	37749
Heat discharged per lb. of gas, 0.23 (1800—100), B.t.u.	391
Area of outside of kiln, sq. ft.	1213
Area of hood exposed, sq. ft.	76
Air entering kilns, deg. fahr.	480
Air leaving kilns, deg. fahr.	1820
Air leaving boiler, deg. fahr.	660
Air leaving economizer, deg. fahr.	450
Temp. of kiln by optical pyrometer, lower third, deg. fahr.	2350 to 2960
Temp. of kiln by optical pyrometer, upper part, deg. fahr.	2960 to 1800

DRYING

Previous to drying, the coal is crushed by passing through rolls plain or toothed, or through crushers, to

TABLE 2 APPROXIMATE DISTRIBUTION OF HEAT

	B.t.u.	Per cent
Heat entering kilns from clinker cooler	2,041,000	
Heat entering kilns from comb. of coal	26,450,000	
Heat produced from chemical reactions	632,206	
Total heat supplied	29,123,206	100
Discharged from kiln to boiler	14,859,859	51.2
Discharged with clinker ($8018 \times 2 \times 500$)	4,409,540	15.1
$CaCO_3$ decomposed (8875 lb. at 765)	6,789,375	23.3
126 lb. sulphuric anhydride liberated	238,140	0.8
252 lb. water evaporated	303,200	1.0
Radiation and unaccounted for	2,523,092	8.6
Radiation per sq. ft. of surface of kiln per hour	974	
Heat absorbed by boiler from kiln gases	8,798,328	30.5
Heat absorbed by economizer from kiln gases	1,178,998	4.0
Stack loss and boiler radiation	4,882,533	16.7

break up the large pieces. For the purpose of drying, rotary cylinders of the general character illustrated in Fig. 3, are generally employed, provided with an external furnace. The rotary cylinder of the dryer is frequently subdivided by partitions, or else provided with Z-bars, which raise the coal upward as the cylinder revolves and bring it into better contact with the heat and gases.

In some of the coal dryers, as Fig. 4, which is a dryer constructed by the Vulcan Iron Works, the discharge gases from the external furnace are arranged to pass through the dryer.

The coal to be dried is fed into the upper end of the cylinder *C*, through the hopper *K*, or other convenient means, and is discharged through the stationary hood *H*, at the lower end of the cylinder. An external furnace is located at *AA*, from which the hot gases pass to the rotating cylinder *C*, through the stationary hood *H*. There is a by-pass at *F*, by which the gases can be made to pass from the furnaces directly into the stack *D*, without having to pass through the rotating cylinder *C*.

The dried coal is usually discharged into suitable conveyors and immediately removed to bins over the pulverizing machines. This adds to the efficiency and

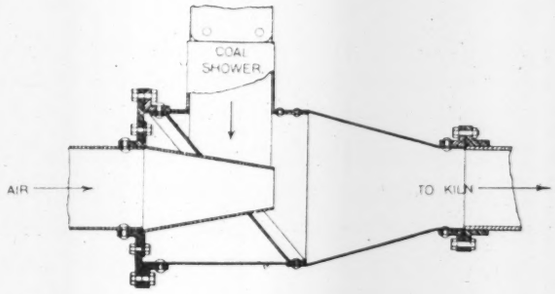


Fig. 7 Low-Pressure Burner

capacity of the dryer but also increases somewhat the danger of conflagration while in the dryer. This danger is slight; however, in practice and with good construction it is quite certain not to result in serious damage, and can always be obviated by care so that the practice is not open to serious criticism.

The coal dryer is frequently provided with a stack to remove the dust. The size of the dryer is usually selected with reference to the maximum amount of moisture to be removed. Large plants usually have from two to three dryers, of sizes varying from 4 by 40 ft. to 6 by 60 ft.

Various other types of dryers of special design and considerable merit are employed in some plants but they can hardly be considered in a paper of this general character.

The waste heat of the plant is available for use in dryers, but the amount of heat needed for the coal drying is so small as to make the installation of the waste heat equipment usually a poor investment. This statement may not apply to other dryers of the plant requiring a greater expenditure of heat.

THE PULVERIZING MACHINERY

The coal, if delivered in large lumps, is broken into small pieces by passing through plain or corrugated rolls or crushers, before entering the dryer. This machinery will not be described here as it is commonly used for such purposes in all arts.

The pulverized coal must finally have a fineness so that not less than 92 per cent will pass a sieve of 100 meshes to the lineal inch, in order to pass the usual

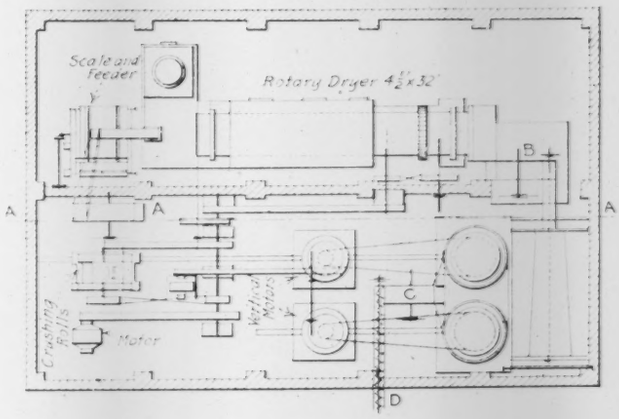


Fig. 8 40-Ft. by 60-Ft. Coal Mill, Machinery Plan

standard requirements. It is desirable to have the coal still finer. The pulverizing machinery employed is adapted to two systems of dust burning. In the first system the pulverizer is arranged so as to deliver its product directly into the kiln without intermediate storage, and has a capacity of supplying one kiln. In the second system the pulverizers have large capacity and are arranged so that the pulverized coal is stored for a short time before being fed into the kiln. The first type of pulverizer is used only to a small extent at the present time. The second type is used almost exclusively in the various cement kilns.

The Aero Pulverizer, which is of the first type, is employed in certain mills of the Universal Portland Cement Company, and consists essentially of a horizontal shaft revolving at high speed which carries beaters or revolving arms throughout a greater portion of its length and fan blades near the discharge end. When it has been sufficiently pulverized to be handled by the blast produced by the fans, it is delivered through an inlet pipe which leads directly to the kiln. The capacity is controlled by suitable dampers in the supply pipe. I am informed by the president of the Universal Portland Cement Company, Mr. Hagar, that his recently constructed mill is equipped with coal pulverizing apparatus with intermediate storage between the mill and the kiln.

The pulverizing machines mostly used in the Portland cement industry for the purpose of pulverizing coal are the Griffin mill, the tube mill and the Fuller-Lehigh mill. These are all fine grinding mills and are not adapted to receive large pieces of coal.

In the Griffin mill grinding is performed by a roll attached to the end of a vertical shaft, which is suspended by gimbal joints from a horizontal driving pulley. The grinding roll comes in contact with the interior surface of a ring of hard steel by which means the grinding is accomplished. The grinding roll, however, has a swinging gyratory motion and is not uniformly in contact against the ring. The pulverizing is therefore accomplished partly by the force of impact and partly by a rubbing motion.

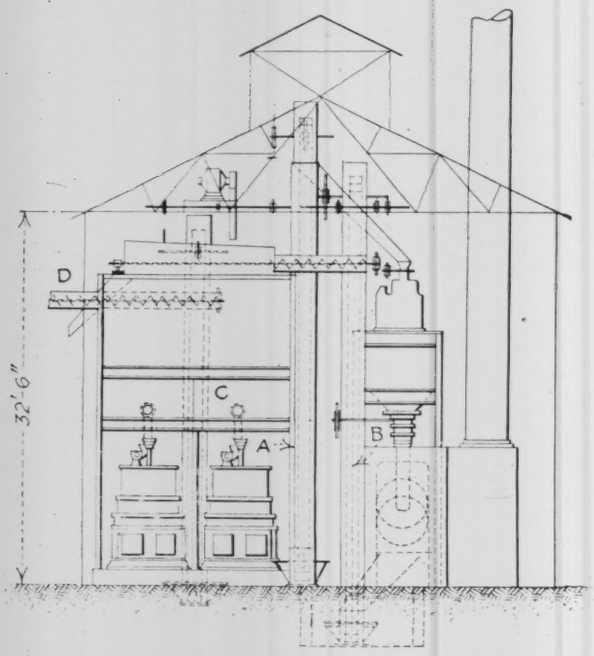


Fig. 9 40-Ft. by 60-Ft. Coal Mill, Dryer and Mill Elevation

The bottom of the grinding roll carries projections which continually throw the coarse particles to be ground from the bottom of the mill up against the internal surface of the ring, where it is pulverized. The ground material is then thrown upward and outward by fan blades attached to the shaft which supports the grinding roll, causing the material to impinge against a screen which allows the fine particles to pass through, but preventing the escape of the coarser particles.

The Griffin mill is a very effective grinding machine and is economical in the use of power. It is objectionable principally because of the dust which it produces. It has a capacity of pulverizing to a fineness of over 90 per cent through a sieve with 100 meshes to the lineal inch, as follows, for the two sizes of mill which have been made:

30-in. mill, 2 tons per hour	35 h.p.
40-in. mill, 4 tons per hour	65 h.p.

The 30-in. Griffin mill is in extensive use but is no longer manufactured.

The tube mill is extensively used for grinding coal, also for grinding rock and finished material in cement mills, and is constructed by several manufacturers. It consists essentially of a large cylinder mounted on hollow trunnions at the ends, a section of which is shown in Fig. 4. The cylinders vary in diameter from 4 to 6 ft. and have a length varying from 22 to 30 ft. The material to be pulverized is fed through a hollow trunnion at one end and is discharged at the opposite end. The cylinder is filled about 40 per cent full with hard silicious pebbles usually somewhat elliptical in form and having diameters not greatly different from 2 in. The mill is lined with some tough materials which can be readily replaced, such as silica blocks or plates of steel.

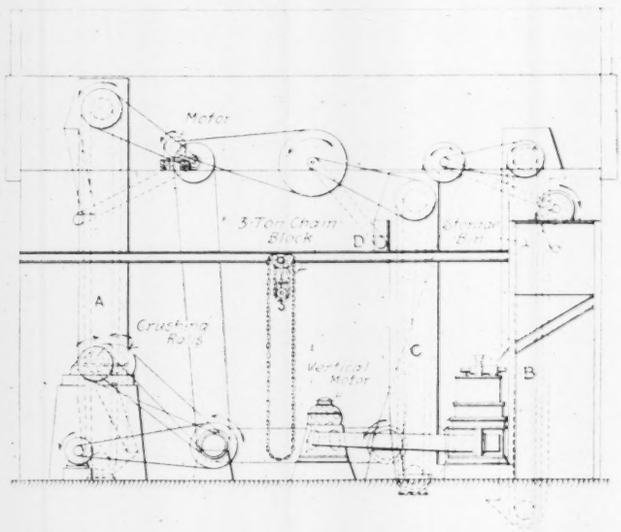


Fig. 10 40-Ft. by 60-Ft. Coal Mill, Elevation showing Fuller Mills

The rotation of the cylinder lifts the load of pebbles and material being pulverized and causes the pebbles to roll and slide over the material to be ground as it passes through the mill. The result is an extremely fine product. The 50-in. tube mill 22 ft. in length has a capacity of about 4 tons of coal per hour and requires about 75 h.p. The tube mill is practically dustless and is noiseless. But it requires very dry coal to be successful.

The Fuller mill is probably the most extensively used of any grinding mill for coal in the Portland cement industry in this country. This mill is a comparatively new one and is manufactured by the Lehigh Car Wheel & Axle Works, at Fullerton, Pa. In this mill the pulverizing element consists of four steel balls which roll in a stationary horizontal concave-shaped grinding ring. The four balls are propelled around the inside

of the grinding ring by means of four pushers. Directly above the pulverizing zone is a separating chamber which is completely encircled by a screen of woven wire cloth. The material is thrown against the screen by a fan keyed direct to the main shaft and revolving with it. Outside of the screen and separated from it by several inches of space is an outside casing through which all the finished material passes. There is also an exhaust fan beneath the pulverizing zone which induces a discharge through the screen and also tends to facilitate the discharge of the ground material. The material to be pulverized is fed from a hopper at the top of the mill by special feeding mechanism to the pulverizing zone. The mill is driven by means of a pulley or gears attached to the main shaft below the pulverizing zone.

The Fuller mill is constructed in two sizes, 33 in. and 42 in. The capacity of the 33-in. mill is given as 2 to 2.5 tons per hour for an expenditure of from 30 to 35 h.p., and of the 42-in. mill as 4 to 6 tons per hour with an expenditure of 45 to 50 h.p.

In addition to the pulverizing mill described in this paper, other mills are employed to a limited extent. The Atlas Portland Cement Company employ Huntington mills for coal grinding which they manufacture in their own shops. The Huntington mill is in structure much like the Griffin mill but it is provided with three pulverizing rolls instead of one.

CONVEYING MACHINERY

I shall make no attempt to describe the conveying machinery employed in modern cement mills for conveying the coal to the various parts of the mill. This machinery differs greatly in the different mills. In the great majority of mills screw conveyors are employed for moving the coal horizontally and bucket and chain elevators encased in dust-proof housings of steel for moving it vertically. In other mills belt conveyors and pan conveyors are used.

The requisite for safe conveying is the prevention of an explosive mixture of pulverized coal and air. Neglect of this precaution has caused the loss of many lives and the destruction of a great deal of property in the Portland cement industry. The present practice endeavors to keep the pulverized coal from mixing with air so that if it should happen to catch fire it would burn slowly without producing disastrous explosions.

STORAGE OF PULVERIZED COAL

Storage capacity for pulverized coal, because of the element of danger, should be as small as possible consistent with the continuous operation of the mill. It is customary to provide for each kiln a storage bin with a capacity of from 6 to 10 hours of operation. Such bins are usually located 15 to 20 ft. from the lower end of the kilns where they do not interfere with the operation. Each bin is supplied by a conveyor leading from the pulverizing machine. The ordinary location with reference to the kiln is illustrated in Fig. 1. In this drawing the coal bin, shown at *K*, is of a cylindrical form with a cone-shaped bottom. The pulverized coal is supplied to the bin through a screw conveyor at the top of the bin, shown at *L*. It is discharged from the bottom of the bin by means of a screw. Coal storage bins of rectangular cross section are equally serviceable.

FEEDING THE COAL

Powdered coal is fed from the bottom of the bin by adjustable feeding arrangements generally consisting of a double-threaded screw conveyor having a variable feed, one type of which is illustrated in Fig. 1. The coal dust is blown into the kiln by a jet of air with some type of injector. In some of the plants com-

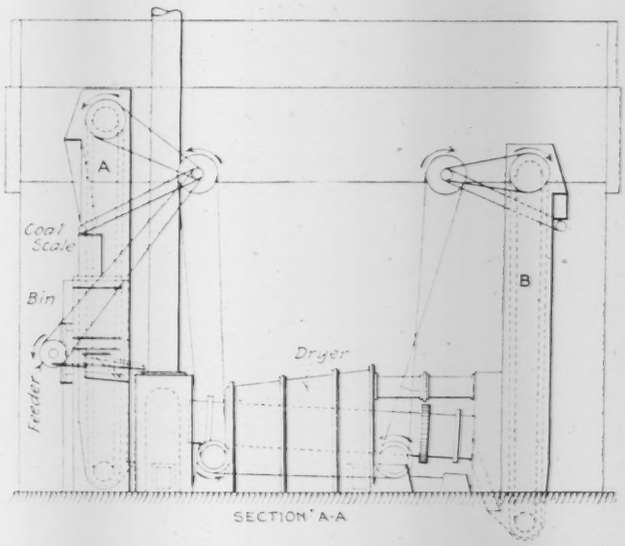


Fig. 11 40-Ft. by 60-Ft. Coal Mill, Elevation showing Dryer

pressed air of from 30 to 40-lb. pressure is employed for delivering the pulverized coal; in other plants air is obtained from a rotary fan at about 2 ounces pressure. Fig. 6 illustrates a type of high pressure burner extensively employed by the Atlas Company. The drawing clearly shows the construction and mode of operation. Fig. 7 shows a common type of low pressure injector. The drawing shows the construction of the injector, from which the mode of operation will be readily understood.

The coal feeding injectors are located in front of the stationary hood and arranged to deliver the jet of coal dust axially to the kiln. Practice has proved that it is unnecessary to use more than one jet to a kiln, although in some of the constructions two jets are used. The detailed construction of injectors for feeding the pulverized fuel differ in the various plants, but all embody the features illustrated in Figs. 6 and 7.

COMPLETE INSTALLATION OF PULVERIZING MACHINERY

I present a set of drawings which show a complete installation of coal pulverizing machinery having a capacity of about 8 tons per hour. These drawings I have selected as illustrating simply and completely the machinery needed for a coal pulverizing equipment. They were prepared by the Lehigh Car Wheel & Axle Works and are submitted by permission. They appear as Figs. 8 to 11 in connection with this article. Fig. 8 is a plan view showing the arrangement of the machinery. Figs. 9, 10 and 11 are vertical sections which show the locations in a vertical plane of various machines. By reference to these drawings it will be noted that machinery is provided for crushing the coal in crushing rolls, elevating the crushed coal in a dust-proof elevator *A*, to the top of the mill where it discharges by gravity through a coal scale and then into the upper end of a rotary dryer. The coal passes through the dryer which removes the moisture, then it is discharged into a dust-proof elevator *B*, and raised to a height sufficient to fall by gravity into the storage bin for dried coal located at a higher level than the pulverizing mills. From these storage bins the coal is drawn by gravity into the pulverizing mills. The pulverized coal is then raised by a dust-proof elevator *C*, to a point where it is discharged into a screw conveyor *D*, leading to the storage bins near the kilns. The drawings show the various machines as driven by electric motors, which is customary in the art. The rotary dryer is of the general type of one already described in this article and has a rotary cylinder 4 ft. 6 in. in diameter by 32 ft. in length.

The paper is intended to give an idea of the difficulties overcome and the results attained in the burning of pulverized coal in the cement industry without referring to many details of construction. The process of burning in the cement kiln is described quite at length in order that the reader may understand the peculiar character of the problem involved in the cement industry and the differences of the combustion processes in that art and in the steam boiler furnace. It is hoped that a full discussion will give additional information on this subject which will tend to improve the efficiency of combustion in all arts.

In the preparation of this article information has been supplied by the Atlas Portland Cement Company, H. J. Seaman, general superintendent, A. G. Croll, assistant superintendent; the Universal Portland Cement Company, Edward M. Hagar, president; the Helderberg Portland Cement Company, F. W. Kelley, general manager; the Cayuga Lake Portland Cement Company, M. E. Calkins, president; the Allentown Portland Cement Company, J. W. Fuller, president. Valuable information and drawings have also been received from the following manufacturers of cement machinery: Allis-Chalmers Company, Milwaukee; Bradley Pulverizer Company, Boston; Lehigh Car Wheel & Axle Works, Catasauqua, Pa.; Power & Mining Machinery Company, Milwaukee; Thomas Prosser & Son, New York; F. L. Schmidt & Company, New York; Vulcan Iron Works, Wilkes-Barre.

PULVERIZED COAL FOR STEAM MAKING

BY F. R. LOW, NEW YORK CITY

Member of the Society

Numerous attempts have been made in the past quarter century to use pulverized coal as a boiler fuel. The published accounts of the various trials are full of promise and apparent accomplishment, but few of the processes have persisted, and only a small proportion of the coal used in steam making is fired in this way.

There have been three broad types of apparatus produced; that of which the Pinther (Fig. 1) is typical, where the prepared coal is emptied into a hopper above a feed-controlling mechanism and carried into the furnace by the natural draft; that having a mechanical feed, as the revolving brush of the Schwartzkopff apparatus (Fig. 2); and that in which the coal is blown into the furnace, as in the Day or Ideal apparatus (Fig. 3).

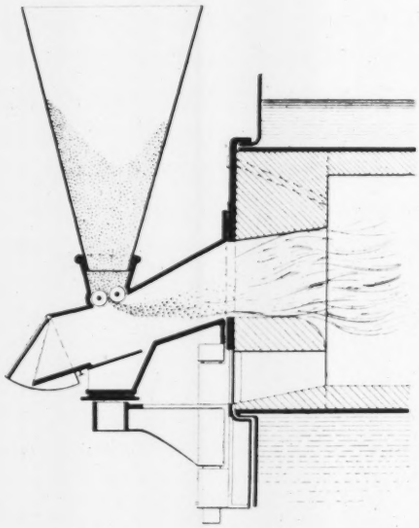


Fig. 1 Pinther Type of Apparatus

With the first type efficiencies of from 75 to 80 per cent were obtained, but the capacity was limited. When sufficient draft was applied to introduce a considerable amount of fuel, the velocity was such as to carry unconsumed particles of coal into the back connection and tubes. When fuel is introduced into a powdered fuel furnace at a rate which will give the full rated capacity of the boiler, a particle will remain in the combustion zone of an ordinary furnace less than half a second.

The first installation that I ever saw for burning pulverized coal under a boiler was of the rotary brush type. It was promoted by Mr. Bradley, an extensive fertilizer manufacturer, I should say in the late nine-

Presented at the Spring Meeting, at St. Paul-Minneapolis, 1914, of The American Society of Mechanical Engineers.

ties. It was but a step from pulverizing fertilizer to pulverizing coal. The apparatus was applied to a horizontal-return tubular boiler at Quincy, Mass., set in the usual way. The brush injector was placed at the furnace door and upon the grate was a thin fire composed of coal of about the size of hickory nuts. There was no way of feeding coal to this fire and none was necessary. Enough of the coal failed to be consumed in suspension, and fell and agglomerated itself upon the fuel bed to keep it supplied. The powdered coal

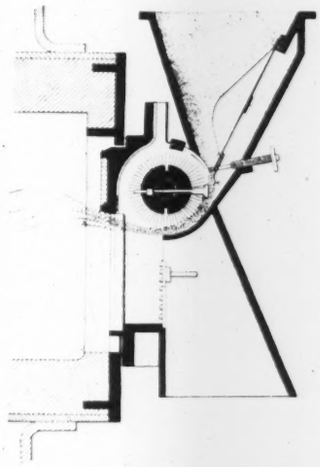


Fig. 2 Schwartzkopff Apparatus

was brought in bags and dumped into the hopper above the brush. The chimney was smokeless, the fire box cloudy, but the combustion chamber full of clean white flame. It looked very promising, but never reached the publication stage.

When it is suggested that an air blast be used to introduce the fuel, the apprehension of an excess of air is natural. The relative volumes of equal weights of coal and air are about 1:990. It would hardly be expected to use less than 15 lb. of air per pound of coal, so that the relative volumes of coal and air introduced would be

$$1:(990\times15) = 1:14{,}850.$$

The diameter of the globe of air which would accompany each tiny particle of fuel into the furnace would be $14{,}850\sqrt[3]{14{,}850}$, or over 24 times the diameter of the particle of coal, so it will be seen that plenty of air may be used for fuel injection purposes without exceeding the supply required for complete combustion. In all of the systems at present in use, the fuel is introduced in this way, the blower usually being so combined with the pulverizer that the pulverized coal is blown into the furnace as fast as it reaches the necessary degree of fineness.

That the subject has not been neglected by inventors is evidenced by the fact that during the past 20 years there have been 23 United States patents issued for pulverized coal apparatus.

The earlier attempts to utilize pulverized coal were in connection with metallurgical processes. J. S. Dawes used it in England, in 1831, in blast furnaces, injecting it with the air through the tuyeres. It was proposed or tried in iron works by Desboissierres, in 1846, by Mouchel, in 1854, and by Mushet, in 1856. Somewhat later, Crampton tried it in locomotive and other boilers.

In the Engineering and Mining Journal of 1876, Chief Engineer B. F. Isherwood, U.S.N., described a test made by naval engineers under his direction in

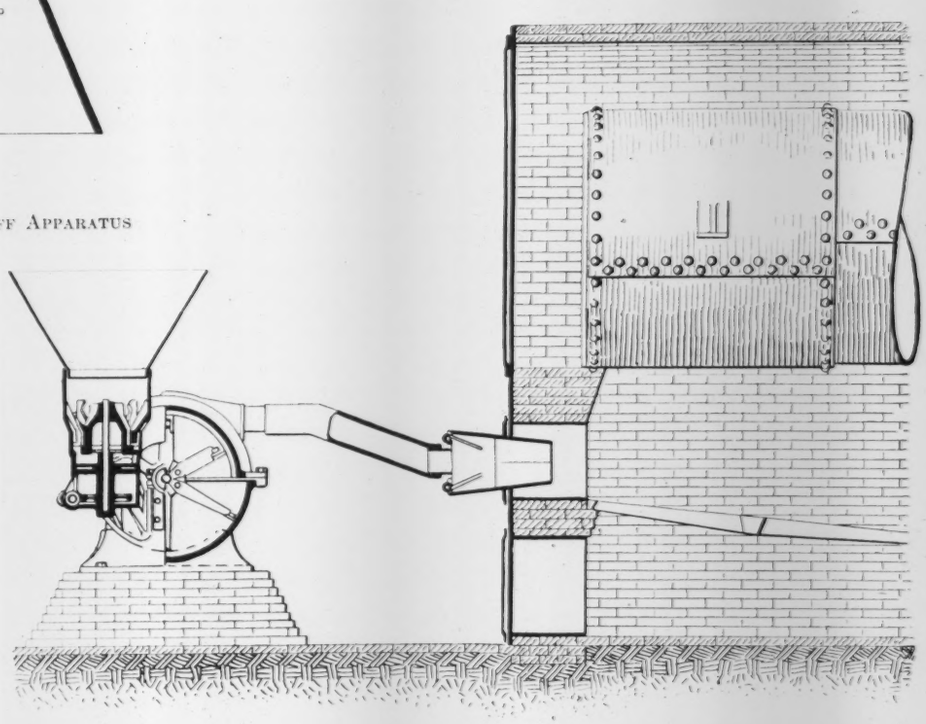


Fig. 3 Day or Ideal Apparatus

1867 and 1868 at South Boston, upon an apparatus devised by James D. Whelpley and his partner, Storer, for firing a boiler in part with pulverized fuel. The boiler was of the horizontal two-flue type having only 299 sq. ft. of heating surface and 13½ sq. ft. of grate. A coal fire was maintained upon the grate and the pulverized fuel fed in above it, a fire arch being used to maintain the furnace temperature when the powdered fuel was used, but not with the grate alone.

Tests were made both with anthracite and semi-bituminous coal. The highest rates of combustion at-

tained were 13.8 lb. per sq. ft. of grate per hour for the anthracite, and 14.9 for the bituminous, referring all the coal burned, pulverized as well as solid, to the grate area. Mr. Isherwood's conclusions were that, including the cost of pulverizing, the anthracite did a good deal better and the semi-bituminous a little better, when burned upon the grate in the ordinary way than when burned in part in the pulverized condition.

In the late nineties, D. Wegener brought out in Europe and tried in this country a natural draft system. Tests showed boiler efficiencies of from 75 to 80 per cent.

In 1910, J. E. Blake, of the Blake Pulverizer Company, installed, under a 300-h.p. water-tube boiler, at the Henry Phipps power plant in Pittsburgh, the arrangement shown in Fig. 4. The pulverizer served as its own blower, sending the pulverized fuel mixed with air to the furnace, where, in this installation, it was introduced by a series of nozzles extending across the width of the furnace. A little less than the rated horsepower of the boiler was obtained with an efficiency of about 79 per cent.

A later form of the Blake apparatus was installed last winter at the Peter Doelger Brewery in New York City. The powdered coal was delivered into the top of an extension furnace or Dutch oven, as shown in Fig. 5. Smokeless combustion and high efficiency were obtained, the principal trouble being from slag, which accumulated on the roof and sides of the furnace, and piled up in such masses upon the floor that frequent shutdowns were required for its removal. They evaporated as much water with 1000 lb. of the pulverized as with 1400 lb. of the natural coal, but the cost of furnace maintenance, the frequent laying off of the boiler for the removal of slag and the cost of pulverizing counteracted in the opinion of the operators these advantages and the system was abandoned after a trial of about eight weeks.

In 1905, John B. Culliney, Superintendent of the American Steel & Iron Company, patented the controlling device shown in Fig. 6. The powdered fuel is deposited in the hopper *A*, filling the chamber *B* directly beneath it, whence it is carried forward by the horizontal screw conveyor and dropped in a continuous stream through the chamber *C*. Radial rods upon the conveyor shaft agitate the mass, and push any foreign or uncomminuted material which may have been introduced with the fuel out to the sides, where swinging cover plates *DD* are provided for its removal. Connected to each side of the chamber *C* is a blast pipe *E*, the opening for which is shown in the longitudinal section at *F*. A current of air flowing through the pipe and across the falling stream of pulverized coal picks up a portion of it and carries it to the larger pipe *G*, where it is taken up by another air current and carried into the furnace. About one-seventh of the total air is supplied at the smaller pipe under a pressure of about 6 oz., the remainder of that necessary to complete combustion being supplied by the larger pipe under a pressure of 1½ oz. or less. The part of the coal which is not taken up by the blast is returned to the upper chamber by the inclined screw of coarser pitch, and carried forward again through the same process. Regulation of the speed of the conveying screws, and of both air supplies, gives the operator complete control of the rate of feeding and character

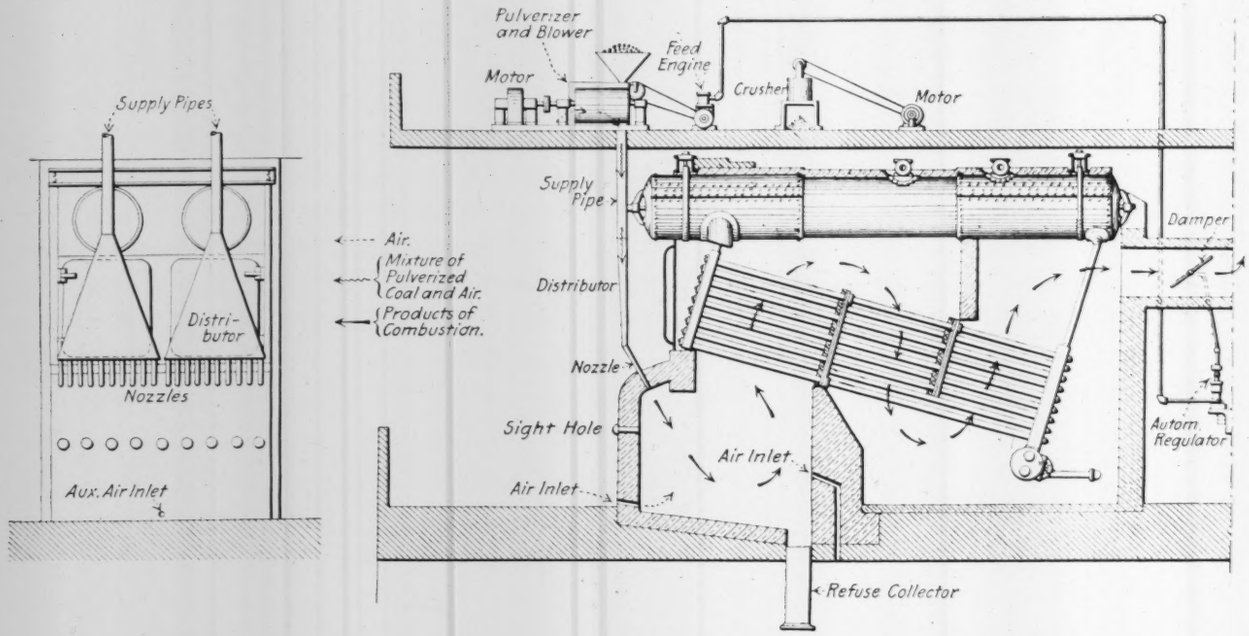


Fig. 4 Blake and Phipps Installation

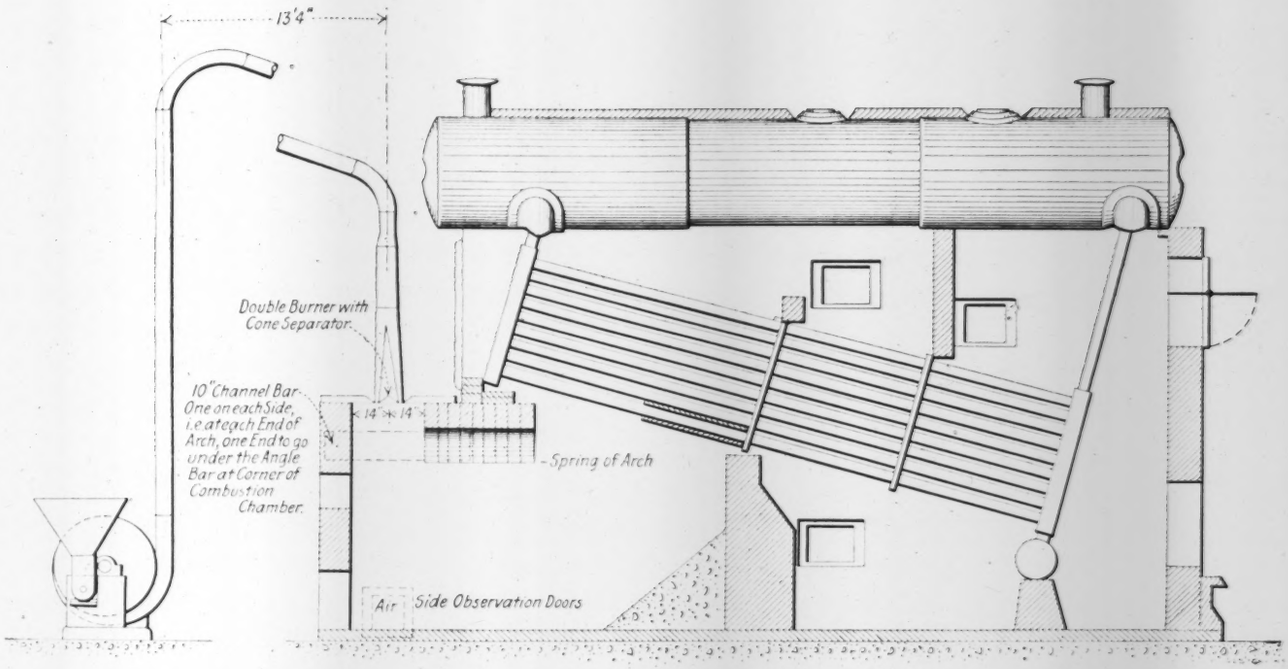
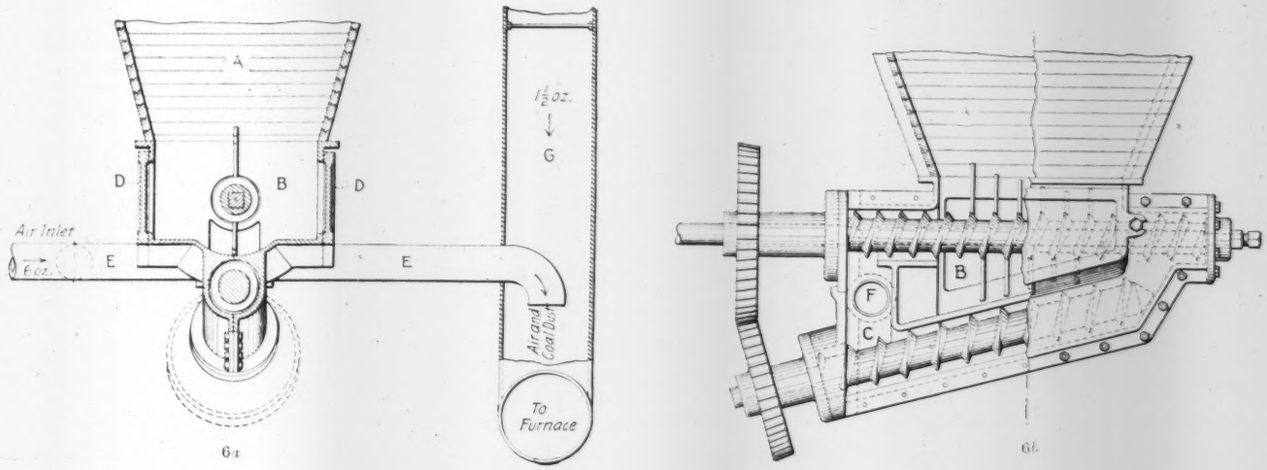


FIG. 5 DOELGER INSTALLATION

of the flame. This system has found a wide application, not only for large metallurgical work, but for many furnaces where oil and producer gas were formerly used, and was used for a number of years under boilers at the works of the Erie Malleable Iron Company until the purchase of current from the electric company made the operation of the boilers no longer necessary.

This system has been for some time in successful use for shop processes at the Schenectady works of the American Locomotive Company, and has recently been installed for steam making purposes under a 300-h.p. Franklin boiler. The arrangement is shown in Fig. 7. The results, up to this writing, have been complete smokeless combustion, no slag, several furnace linings melted down, but inability to get full boiler capacity. This is laid to limited controller capacity, and larger controllers are being installed. It is hoped that further information will be available before the date of the meeting.

Claude Bettington of Johannesburg, South Africa, where the price of coal is high, attacked the problem by designing a boiler especially for use with pulverized fuel. He took out his first patent in the United States, but his boiler was first commercially exploited in England. He met his death in an aeroplane accident some two years ago. In his boiler the feed is upward, as shown in Fig. 8, through a water-jacketed nozzle in the center of a vertical furnace. The pulverizer acts as a blower, and the air supply is preheated. From the



FIGS. 6a AND 6b CULLINEY FEEDING

pulverizer the coal passes to a separator, where the larger particles settle out and return to be again treated, the finer passing on to the burner. The blast, about 2 in., opposing gravity, tends to keep the coal in suspension, and as a particle would have to pass twice the length of the furnace (upward and downward) to escape, there is no difficulty in obtaining complete combustion.

The flame does not lift more than 10 per cent under the highest rate of feed which it is practicable to employ, the temperature of the furnace and of the enveloping gases being increased enough to offset the greater velocity of ingress. The tubes of the inner row of the circular furnace are covered with a special refractory covering to within a short distance of the bottom header, making a brick-lined combustion chamber. The special bricks are placed loosely around the tubes, but soon become coated with molten ash and slag, which welds them into a solid wall, and closes the crevices between the lining and the top header. The ash which is not so slagged to the furnace surfaces, or carried out by the draft, drips into the ashpit below the lower header. The destructive effect of the impinging flame upon the brickwork is avoided by taking it upon the lower head of the central drum, or upon the accumulation of gas in the upper end of the chamber, the region of greatest heat intensity being in the core, while the tubes and shell are subjected to the lesser temperature of the somewhat cooled gases, which have not yet got away. The radiant heat is, however, effective upon them and the metal surfaces must be kept perfectly clean, and particular care taken as to the water level. One of these boilers having 2606 sq. ft. of heating surface has been running for over four years at the works of the builders. It evaporates regularly 14,000, and has been worked up to 22,000 lb. of water per hour. These rates, however, (5.4 and 8.4 lb. per sq. ft. of heating surface) are attained with stoker fired boilers.

A contributor to Power who has had two of these boilers in charge says that the steel head of the upper drum burned through at one time, probably due to dirt collecting upon it; that in spite of the cooling effect of the tubes the special bricks forming the furnace quickly burn away, and frequent renewals are necessary. Care must be taken lest the lining burn through and the gas be short-circuited. Although this boiler will burn low-grade fuel successfully, and while under steam is easily managed, one fireman being able to look after several boilers, these advantages are largely offset in his opinion by high cleaning and maintenance charges.

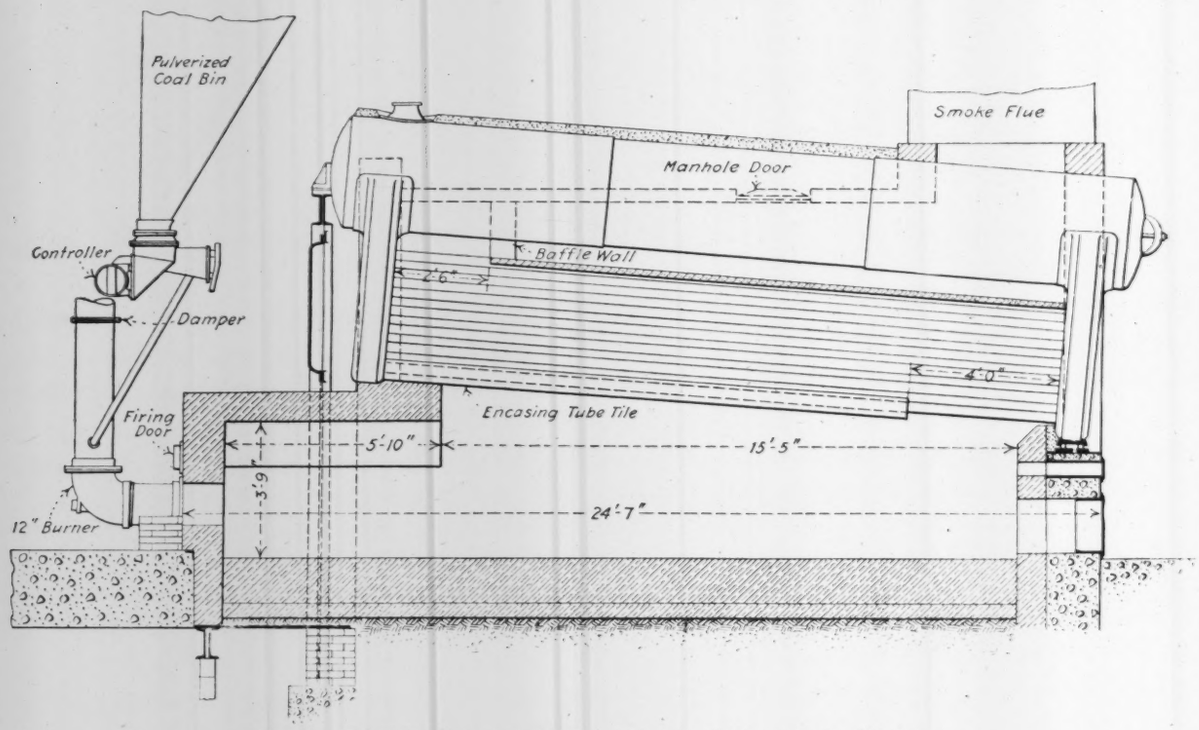


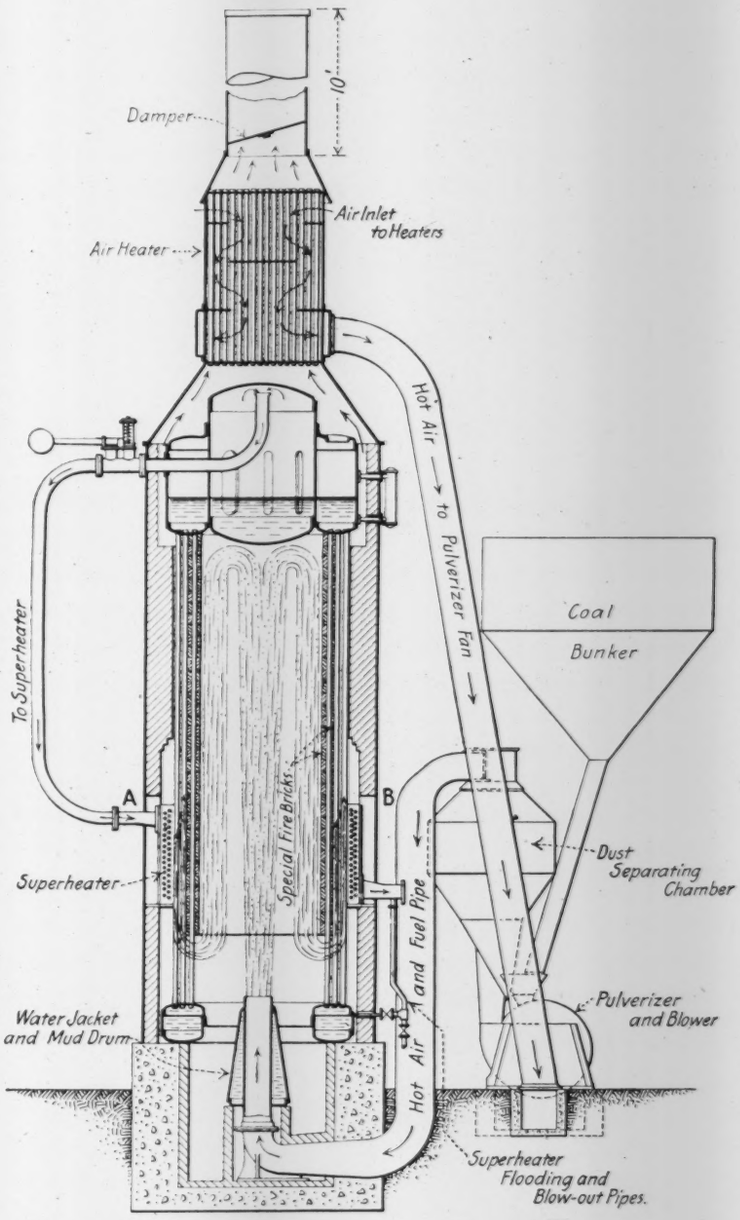
FIG. 7 300-H.P. FRANKLIN BOILER, AMERICAN LOCOMOTIVE COMPANY

The makers say their experience has been that a lining will last about two years, and that even large holes will automatically seal up. The parts which require most frequent renewal are the beaters and liners of the pulverizer. These are of manganese steel, and can be replaced in about two hours. The makers claim an approximate life for the beaters of 1500, and for the liners of 2000 tons of coal handled. A user, after 10 months' experience, says that the blades run from 1000 to 1200 hours per set, and that the second set of liners

was still in use. The use of heated air in the pulverizer allows coal having 15 per cent or more of moisture to be handled successfully; a separate heater is recommended for large boilers. They allow 2 to 3 per cent of the boiler capacity for pulverizing. There was some trouble from leaky water jackets putting the flame out, but this has been overcome by the use of welded jackets.

A number of these boilers are in use in South Africa, in Great Britain and Canada. Tests of one of the Rand boilers show an efficiency of 82.6 per cent, the coal having 2.15 moisture, 22.8 volatile, 57.55 fixed carbon, 17.5 ash. The CO_2 is carried at 15 per cent in regular practice.

With the ordinary method of burning coal, the grate with its bed of solid incandescent fuel more or less encumbered with ash and clinker, offers a considerable, a varying, and an uneven resistance to the passage of air, rejects the incombustible residuum with some difficulty and allows some of the unburned fuel to sift to the ashpit or to be fused in with the clinker. If the fuel can be burned in suspension, many of these difficulties disappear and the draft-producing apparatus is reduced to that which will remove the products of combustion and allow enough air to enter to burn the required amount of fuel. There still remains, however, the difficulty of getting rid of the incombustible. With 10 per cent ash there will be 200 lb. of refuse to be got rid of with each ton of coal burned. If this is kept in a pulverized form it is carried into the back connection, the tubes and stack, and scattered about the neighborhood. If it is fused it attaches itself to the surfaces of the furnace and welds itself into masses, occasioning damage to the brickwork in its removal and comparatively frequent layoffs for cleaning. In one instance the molten slag formed in sheets and ridges upon the sides and in stalactites upon the roof of the furnace, while the floor was covered with a plastic mass, which cooled when the door was opened for its removal, and could hardly be got out without material damage to the furnace.



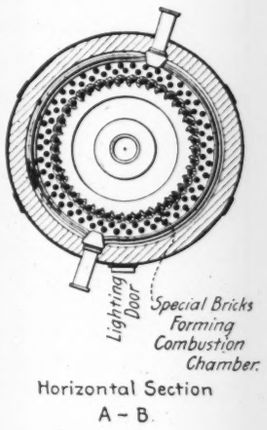


FIG. 8 BETTINGTON BOILER

The possibility of getting an adequate supply of oxygen to the finely comminuted carbon allows perfect and smokeless combustion with a minimum air supply, but with the rates of combustion demanded in present prac-

tice, the result is a high temperature with erosive and reducing characteristics which, however good they may be for metallurgical processes, are not favorable to the longevity of a boiler furnace. If this temperature is kept down by feeding less fuel, the capacity is limited, while if it is kept down by using an excess of air the economic advantage just cited is sacrificed.

There have been several disastrous explosions of the prepared fuel outside of the furnace; but these can be easily guarded against. Coal, however finely comminuted, does not contain the elements necessary for its own combustion, and if ignited will burn only slowly if kept in a compact mass. It is only when it is diffused in a cloud that the oxygen of the atmosphere can get to it quickly enough to make the rate of combustion dangerous. The pulverized fuel can be safely conveyed en masse in suitable holders, in screw conveyors, or even in cars and barrows if care is taken that it shall not be blown or sifted about in a finely disseminated state. In those systems where the pipe back of the blower is filled with an explosive mixture of coal and air, the rate of flow must exceed that of the propagation of flame in such a mixture, and in shutting down the coal supply should be shut off first. The pulverized mass will run like water, so that the pitch of chutes, conveyors, etc., must be so set as to provide against the flowing of their contents.

While anthracite dust can be used it burns more slowly than coal having a higher percentage of volatiles, and must be very finely pulverized. For most systems practically all of the coal should go through a screen having 100 meshes to the inch, and for coals having a small percentage of volatile or where very rapid combustion is imperative the coal is ground to a fineness which will permit the greater part of it to pass through a 200-to-the-inch sieve. Low-grade coals and coals having a large percentage of ash can be burned in this way, but there is a limit to the proportion of slate and bone that one can afford to grind, and an increasing proportion of ash means increased trouble from dust and slag. The earlier practice of taking up the impingement of the flame on a checkerwork or a heap of brickbats is out of favor. It simplifies the process of keeping the burner lighted, but burns up too much firebrick and makes a locus for the building of a slag heap. With an ordinary firebrick furnace well heated up there is no trouble in maintaining the flame steady, and it will re-ignite after having been turned out for several minutes.

The cost of pulverizing and the large initial cost of the drying, pulverizing, conveying and feeding apparatus, together with the fact that coal of practically all grades can be burned with a tolerable degree of smokelessness in the cheaper apparatus in common use with a degree of efficiency which leaves little margin to cover the increased expenditure, have combined to restrict the use of pulverized coal for boiler purposes to special instances.

AN INSTALLATION FOR POWDERED COAL FUEL IN INDUSTRIAL FURNACES

BY WILLIAM DALTON, SCHENECTADY, N. Y.

AND

W. S. QUIGLEY, NEW YORK

Members of the Society

At the works of the American Locomotive Company, Schenectady, N. Y., there have been in use oil furnaces for heating the blanks for drop forgings and general small forge work, and hand-fired coal furnaces for the heavier work in the hammer shop. The equipment is now being changed to burn powdered coal fuel and a milling building has been erected to contain the coal drying and pulverizing apparatus.

The advance in the price of fuel oil in 1912 and the refusal of the oil companies to guarantee deliveries or to renew contracts for any considerable length of time led to an investigation in order to determine what fuel would be a satisfactory substitute for oil.

The apparatus installed was that developed by the American Iron and Steel Manufacturing Company at their Lebanon and Reading works and now handled by the Quigley Furnace and Foundry Company, New York. The plant was built and started in May, 1913, and while there has been the usual amount of trouble in getting a new fuel system to run smoothly, the results have been satisfactory.

The coal milling and distributing plant is motor-driven and centrally located in a building of non-combustible construction. At present it has a capacity of 5 tons an hour, and is so arranged that by duplicating the dryer and pulverizer its capacity can be doubled. This plant has a concrete hopper placed under an elevated track where it can be served either by discharging directly into it from the car or from the stock pile by means of a traveling crane and grab bucket. The concrete car hopper discharges into a rotary crusher capable of reducing 20 tons per hour of run-of-mine coal to ¾-in. cubes, from which it is carried by means of a bucket elevator to a storage bin which discharges by means of chutes and reciprocating feeder into an indirect-heat type dryer of 6-tons per hour capacity. From here it is elevated to a dried coal storage bin arranged to feed by chutes directly into the pulverizer, then elevated to a pulverized coal storage bin, from which it is distributed by screw conveyors to the drop forge and hammer shops. The plans permit of further extension to the blacksmith shop, power plant and other departments later (Figs. 1, 2 and 3).

The milling building is detached, well ventilated, and built in conformity with the underwriters' requirements and accepted by them on a par with buildings

Presented at the Spring Meeting, at St. Paul-Minneapolis, 1914, of The American Society of Mechanical Engineers.

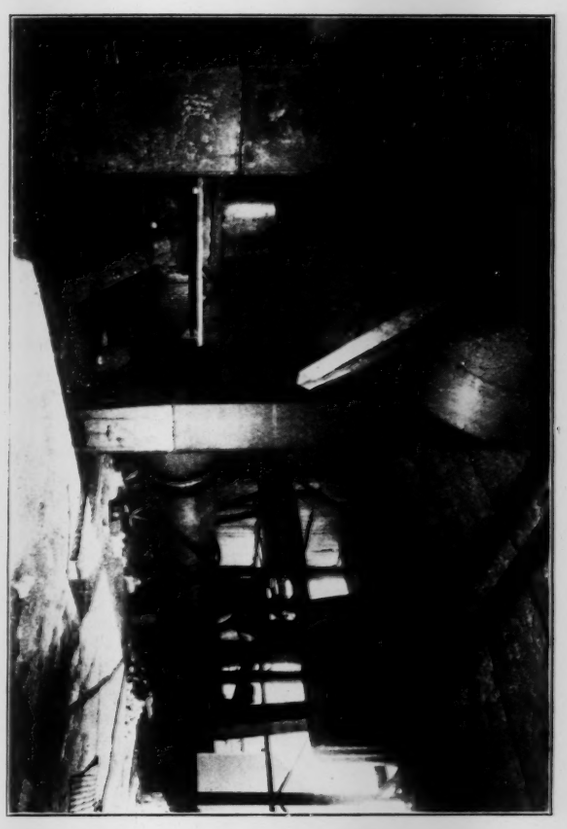


Fig. 1 Milling Building, showing Bins, Dryer, Pulverizer, etc.

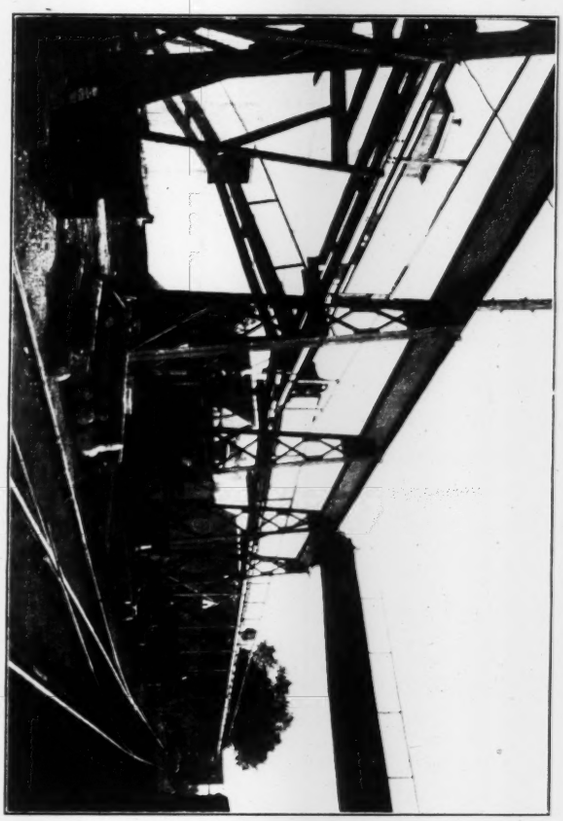


Fig. 3 Conveyor System from Milling Building Supplying Lines Running to Hammer and Drop-Shops

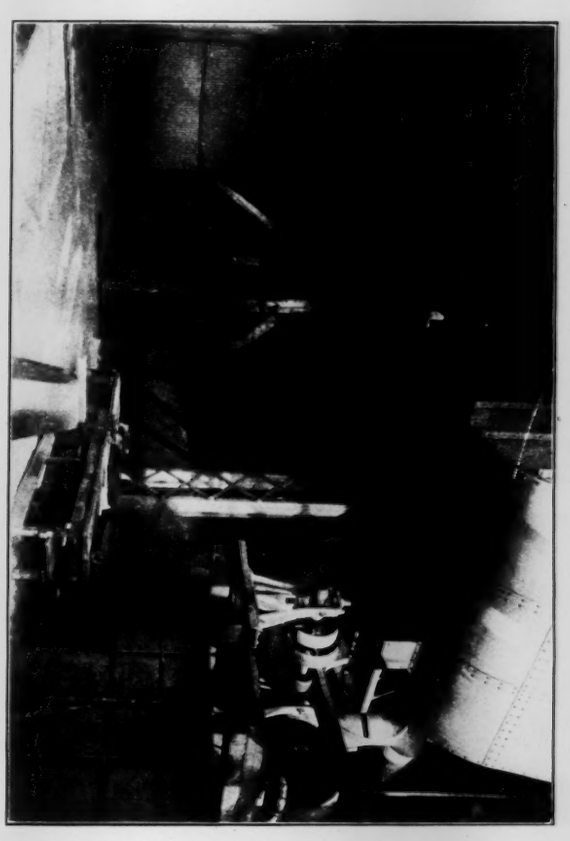


Fig. 2 View from Opposite Side of Milling Building

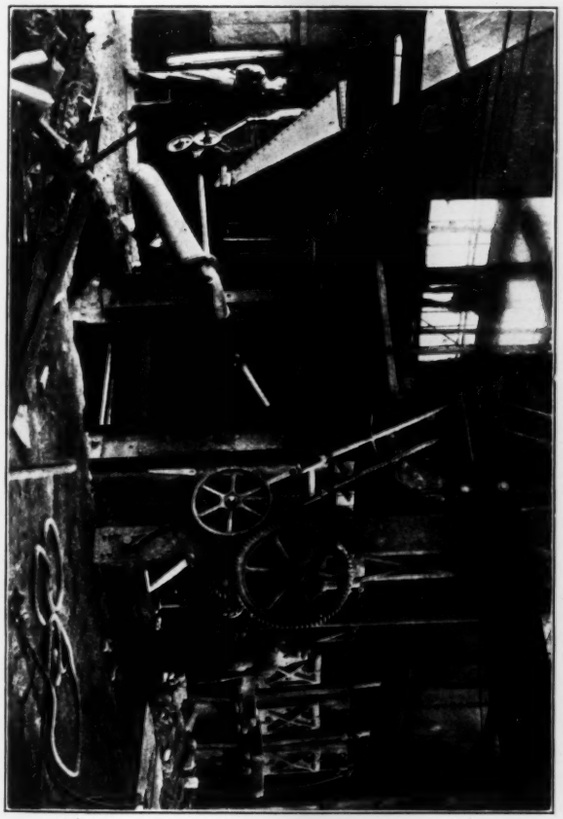


Fig. 4 Three-Door Furnace with Waste-Heat Boiler, on which Tests were Run

containing equipment for fuel oil or gas for industrial purposes. There has been no trouble whatever from spontaneous combustion, or fires from other causes, and there appears to be no reason to expect trouble from this source if ordinary precaution is used, as required with any other kind of fuel.

To insure the best results, the coal should be of high volatile and low ash and should be dried so as to contain not over ½ of 1 per cent of moisture, care being taken in drying to avoid overheating and so driving off any of the volatile content. The coal should be pulverized to a fineness that will permit 93 per cent to 95 per cent to pass through a 100-mesh sieve, and for some classes of work even a greater degree of fineness has been found desirable.

In the burning of powdered coal, the fuel controlling device is the most essential element in the successful operation of the system as a uniform and controllable supply of the powdered coal must be supplied to the burner at all times. The controller used in this installation as shown in Fig. 9, was developed by the American Iron and Steel Manufacturing Company, and used successfully by them for seven years.

The device is motor driven and consists mainly of two screws, the upper located so as to propel the powdered coal from the bin forward to a point where it falls in a stream past an opening through which a cross current of low pressure air (a small portion of the total amount of air required for combustion) is directed, so as to force the desired quantity to the burner through suitable pipes. The lower or return screw is of greater pitch than the upper and returns the excess coal to the base of the hopper. By this method a continuous stream of coal passes the opening and any portion up to the capacity of the upper screw may be utilized by increasing or decreasing the cross jet, and as the lower screw has a greater capacity than the upper it is impossible to clog the device in case of stopping the consumption of coal altogether.

The furnaces in the drop shop are rebuilt oil furnaces and those in the hammer shop are rebuilt hand-fired coal furnaces, and it should be emphatically stated that it is a serious mistake to attempt to apply powdered coal to existing furnaces without rebuilding them in a manner best suited to that fuel, since rapid and economical operation, as well as the elimination of the ash, cannot be accomplished without properly designing the furnaces for the new fuel. Coal has been burned in this plant with an ash content as high as 18 per cent with uniformly good results, although the high ash causes considerable annoyance where open furnaces, such as used for heating small forgings, rods, etc., without doors are used or where doors are not wholly closed during operation, unless efficient hoods or an exhaust system for properly disposing of the small particles of escaping ash is installed.

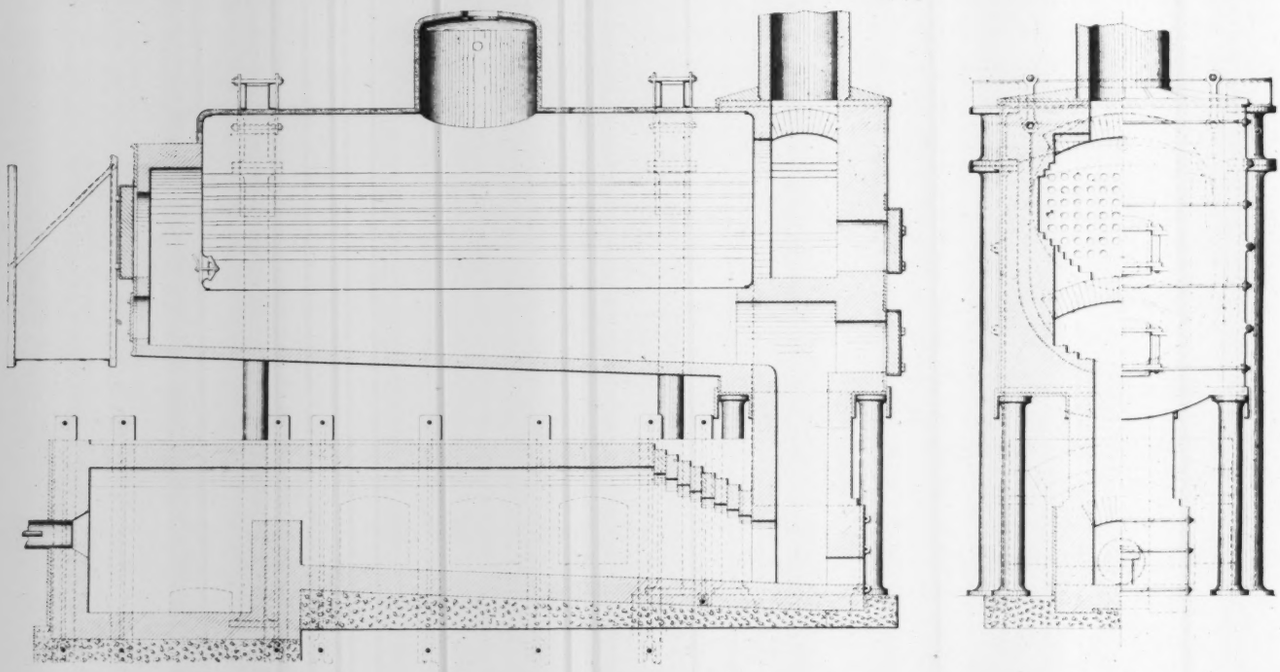


Fig. 5 Diagram of Three-Door Furnace with Waste-Heat Boiler, Shown in Fig. 4

The foregoing gives in a general way a description of the important features of the plant. After the first two furnaces were equipped in the drop shop and one in the hammer shop, tests were made to determine the savings effected with the use of powdered fuel as compared with fuel oil and hand-fired coal practice; and also as to what changes needed to be carried out in the alterations upon the other furnaces. The results of

the tests upon these first furnaces are here given.

TEST ON POWDERED COAL FURNACE NO. 3335

Nov. 12, 1913: Started 12 m., ran to 4:07 p.m. Heat in at 12:30.

Nov. 13, 1913: Started 6:15 a.m., ran to 12:30 p.m. Heat in at 7:28.

Furnace ran eleven heats, five heats of 10 pieces and 6 heats of 12 pieces. Worked on pedestal die wedge.

November 12

HEATS	TIME, MINUTES	FORGING TIME, MINUTES	PIECES
1	23	19	10
2	24	18	10
3	23	17	10
4	28	18	10
5	21	17	10

November 13

1	41	20	12
2	22	29	12
3	24	21	12
4	23	22	12
5	24	22	12
6	22	22	12

Actual time 10 hr. 22 min. Coal burned 2177 lb. Low-pressure blast 1 oz. from 8 in. pipe reduced to 6 in. at burner. High-pressure blast 8 oz. from 4½ in. pipe reduced to 1½ in. at controller and 2 in. leaving controller. Motor on controller ⅜ h.p., 1.85 amp., 230 volts. 50-in. blower on low-pressure air runs 825 r.p.m., driven by 10 h.p. a.c. motor, 20-in. galvanized iron pipe connection.

The coal was measured as follows: Started with coal at a marked level in the hopper and after the test filled the hopper to the starting mark with coal weighed in bags, weight of bags subtracted.

COAL ANALYSIS

Ash	14.12
Volatile matter	20.28
Fixed carbon	64.60
	100.00
Fineness	98.4 per cent
B.t.u.	13,220

TEST ON OIL FURNACE NO. 5078

Nov. 14, 1913: Test started 6:10 a.m., ran to 3:35 p.m.

Furnace ran eleven heats, 12 pieces to each heat. Worked on pedestal die wedge.

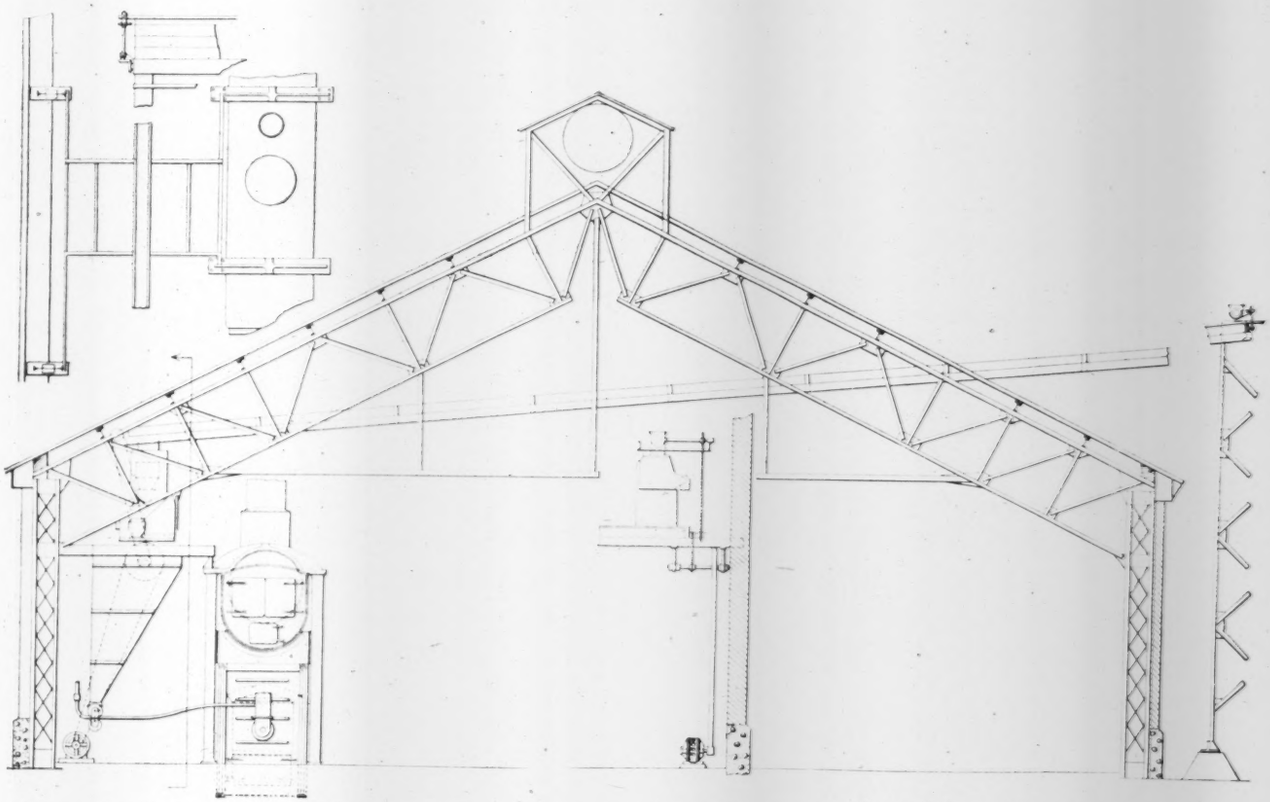


FIG. 6 CROSS-SECTION OF HAMMER SHOP SHOWING LOCATION OF CROSS CONVEYOR, SCALE, POWDERED COAL HOPPER AND THREE-DOOR HAMMER FURNACE

HEATS	TIME, MINUTES	FORGING TIME, MINUTES	PIECES
1	31	18	12
2	25	18	12
3	20	16	12
4	21	19	12
5	23	18	12
6	21	17	12
7	40	22	12
8	28	16	12
9	21	16	12
10	23	17	12
11	31	16	12

Actual time 9 hr. 25 min. Oil used 1238 gal. Blast on oil burner 6½ oz. from 6 in. pipe reduced to 4 in. at burner. 120 h.p. A. C.

Motor runs three No. 10 Sturtevant Blowers for blast. Blast, 1½ h.p. per hr.

The oil was measured as follows: There were two tanks with gage glasses at the bottom, so that the exact level of oil could be determined; the tanks were so connected that one could be filled with oil while the other supplied oil to the furnaces. The tanks were accurately calibrated and the oil consumption computed accordingly.

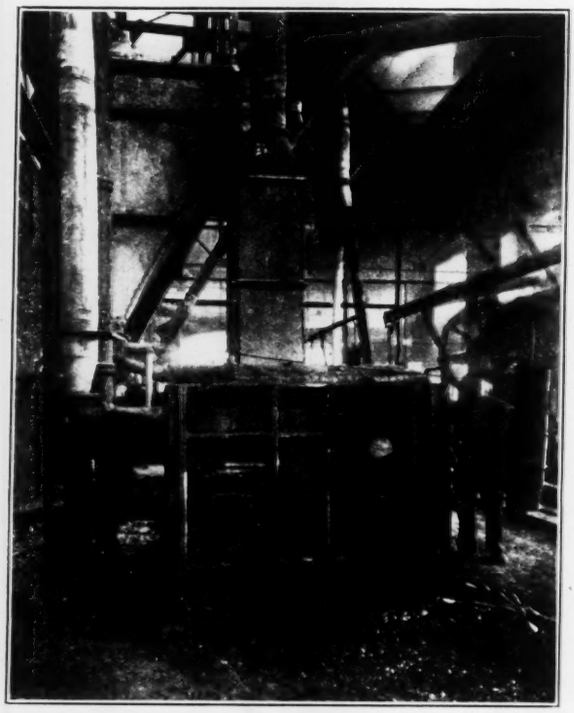


Fig. 7 Furnace Heating Blanks for Drop Forging on which Tests were Run

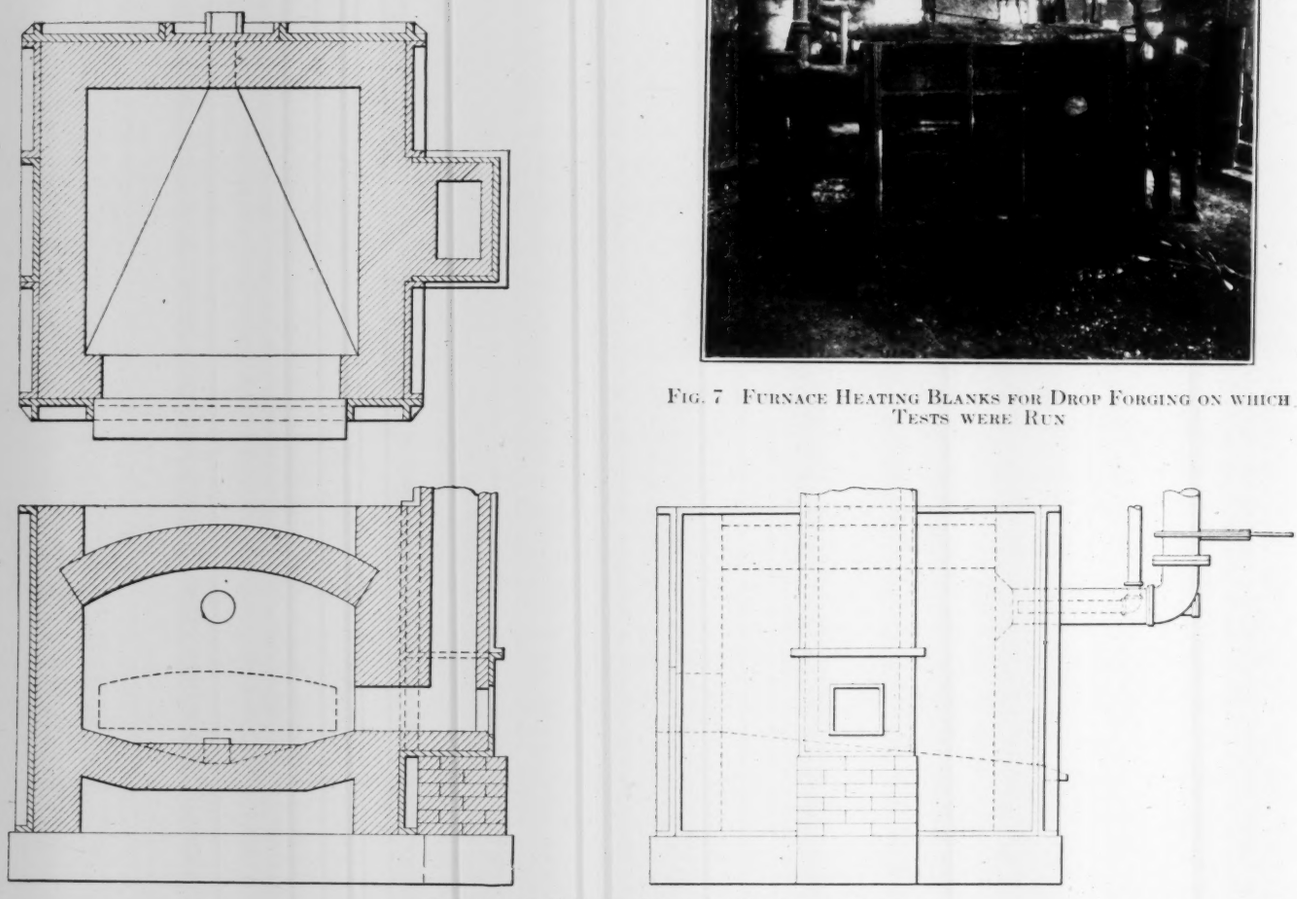


Fig. 8 Diagram of Furnace, Shown in Fig. 7

Comparison of Pulverized Coal Furnace No. 3335 and Oil Furnace No. 5078 (Both Same Size) in Drop Shop

	Pulverized Coal Furnace No. 3335	Fuel Oil Furnace No. 5078
Hours run	10 hr. 22 min.	9 hr. 25 min.
Fuel consumed	2177 lb. coal	138 gal. oil
Average time per heat	25.1 min.	25.8 min.
Average time per forging	1.87 min.	1.47 min.
Actual forgings	122	132
Forgings to be counted	132	132
Cost of fuel at contract price	$2.82 ($2.56 ton)	$6.69 (4.8 ct. gal.)
Cost of fuel delivered to the furnace	$3.31	$6.89

The powdered coal furnace ran 57 min. longer than the oil furnace. However, 30 min. were lost because of failure to charge furnace on November 12 and 18 min. were lost on November 13, because plate for heating dies was not put in at the proper time.

The work was on pedestal die wedges, which are of iron. The blocks weigh 25 lb. and the forgings 16 lb. The time lost on the pulverized coal furnace would more than allow for making the 12 forgings, so that the amount turned out by each furnace should be considered equal as indicated in the table above.

Some weight should be given the fact that the oil costs were probably kept at a minimum, as the heater was thoroughly familiar with oil and was able to obtain the maximum heat with the minimum amount of fuel oil. The same men ran each furnace and the only fac-

tor of importance was that the ram used on the hammer at the oil furnace was about 500 lb. heavier than the ram on the hammer at the coal furnace. This did not affect the time of heats, but allowed a quicker forging time, and there was less time lost with nothing in the furnace.

It will be noticed from the coal analysis that the coal contained over 14 per cent of ash, which is too high for the efficient use of pulverized coal. The volatile matter analyzed low, but as this coal has been running above 30 per cent in volatile matter, it is believed there must have been some fault in the analysis.

The above results show the cost of operating the furnace on pulverized coal during these tests was 48 per cent of operating it on fuel oil at the present price.

In comparing the maintenance of the two styles of furnaces, the pulverized coal furnace had not been run long enough to make an accurate comparison, but indications are that the maintenance of the pulverized coal will not exceed that on the old style and will probably run less. The saving in labor with the pulverized coal furnace is shown to be:

Three men on ashes at $1.75	$5.25
Three men on fires nights at $2.10	6.30
Per 24 hours run	$11.55

Based on the shop running at average capacity there would be a labor saving of $11.55. This allows for men to start furnaces in the morning and wheel away ashes and slag.

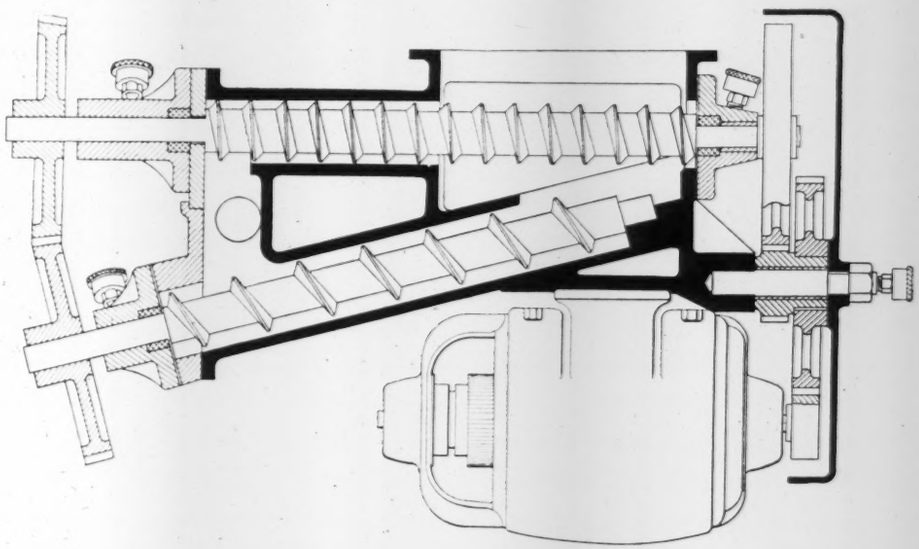


Fig. 9 Motor-Driven Controller

Comparision of Tests on Large 3-Door Forge Furnaces of Same Size Under Waste Heat Boilers Nos. 45 and 61

No. 45, old style furnace burning mine run coal, hand-fired. Nov. 12, 1913.

No. 61, new furnace equipped to burn pulverized slack coal. Nov. 21, 1913.

	Boiler No. 45 Mine Run Coal	Boiler No. 61 Pulverized Coal
Hours run	10 hr. 5 min.	9 hr. 30 min.
Fuel consumed	4630 lb.	3200 lb.
Average time per heat	117 min.	120 min.
Cost of fuel actually delivered	$6.69	$4.14
Tonnage per furnace	9920	9920
Cost of milling, conveying and blast	$0.48	$1.04
Total cost of fuel burned	$7.17	$5.18
Cost per ton output	$1.45	$1.05

Both furnaces ran under favorable conditions and the men on both hammers turned out a fair average day's work. Both furnaces were on the same class of work and heated the same amount of material.

In comparing the coal the analysis given below shows that there is too high a percentage of ash in the slack coal; otherwise the samples are representative of the two grades of coal used.

Coal Analysis, Boiler No. 45

Sulphur	1.26
Ash	5.52
Volatile matter	29.17
Fixed carbon	65.31
B.t.u.	13,826

Stack temperature 340 deg. fahr.
Blast on furnace 9½ oz.

Coal Analysis, Boiler No. 61

Sulphur	1.27
Ash	13.72
Volatile matter	30.18
Fixed carbon	56.10
B.t.u.	13,132

Stack temperature 240 deg. fahr.
Blast on furnace 1 oz.
Blast on coal 6 oz.

From these reports it will be noted that the air pressure required for burning powdered coal is materially less than that used on either oil or hand-fired coal furnaces. Owing to this decrease it was found necessary to lengthen the stack on the waste heat boiler to increase the draft and afford a better circulation.

TOPICAL DISCUSSION

Following the presentation of the papers upon Pulverized Fuel, there was a topical discussion for which contributions had been prepared by J. L. Agnew, W. P. Barba, H. G. Barnhurst, John V. Culliney, W. R. Dunn, William A. Evans, Edw. J. Kelley, A. W. Raymond. These contributions were sent to the Society in response to an invitation to furnish data upon the following selected topics:

(1) Grades of coal successfully used—analysis
(2) Experiences with coal high in ash and sulphur
(3) Essentials of storage bin for powdered fuel—troubles from storage
(4) Necessity for drying coal before grinding
(5) Fineness of grinding
(6) Cost of grinding and handling, including upkeep
(7) Danger from particles of dust floating in air
(8) Essentials of a good burner
(9) What troubles are likely to occur with burners in general
(10) Special features required in powdered fuel furnaces
(11) Air pressure used and effect of stack draft on combustion
(12) Experiences with ash or slag in furnace
(13) What temperatures are maintained in furnaces—influence of temperature on formation of slag
(14) Experiences with checkerwork in metallurgical furnaces
(15) Life of furnace as compared with furnaces using other fuels
(16) Items of expense or economy in the plant as a whole, due to use of powdered fuel

The contributions are as follows:

(1) *Grades of Coal Successfully Used—Analysis.*

A good average analysis of the coal used here is as follows:

Volatile matter	39
Fixed carbon	53
Ash	8
Sulphur	2
B.t.u.	13,600

The amount of volatile matter present is probably of considerable importance, but we are not able to say from our own experience how high the fixed carbon could go and the coal still be successfully used in the powdered form, though it is stated that anthracite and even coke has been used.—J. L. Agnew.

The kinds we have used successfully are high-grade gas coals and gas slacks where the volatile has run about 35 per cent to 40 per cent, ash 6 per cent to 8 per cent and the sulphur low.—W. P. Barba.

Coal most suitable for kiln furnaces and other types of metallurgical furnaces is that which runs about 35 per cent in volatile combustible matter, 8 per cent or lower in ash, and 1½ per cent or lower in sulphur. Good results are being obtained, however, on coals which vary considerably from the above percentages.—H. G. Barnhurst.

The grade of coal successfully used in heating and puddle furnaces has a composition closely approaching the following:

Volatile matter	33
Fixed carbon	56
Moisture	1
Ash	9
Sulphur	1
	100

—John V. Culliney.

What is technically known as gas slack is the grade most generally used, particularly in the Portland cement industry. This is cheaper than run of mine gas coal, and in its fine state dispenses with the use of preliminary crushing machinery prior to going to the dryer. The coal should be high in volatile matter. Its range in this respect should vary from 28 per cent upward. The higher the volatile content, the more readily will the coal ignite, provided, of course, the fineness be the same. The volatile matter is driven off after the small percentage of moisture. It is readily ignited by the heat of the furnace, and, if the coal has been sufficiently reduced in fineness and properly mixed with air, the burning coal dust will approach the condition of an approximate gas. A typical analysis of a high-grade gas coal would be as follows, figured on a dry basis:

Volatile matter	34.50
Fixed carbon	57.00
Ash	8.50
Total	100.00
Sulphur	1.20

The value of a coal for a particular industry will depend greatly upon the character of the particular furnace and especially upon the material to be heated. For example, a coal high in sulphur may be used without deleterious effect in one industry, while in another it would cause a great deal of harm to the material being treated. Coals high in sulphur invariably give trouble, due to spontaneous combustion. This is especially true with some of the high sulphur coals of Indiana and Illinois.—W. R. Dunn.

Furnaces have been operated using coal with ash as high as 18 and 20 per cent, but the successful use of such coal is limited to those furnaces in which the deposit of ash on the charge of material does not seriously affect the product. For most furnaces of the rotary type and for heating furnaces, moderately good coal will do, that is coal containing 8 to 10 per cent ash. On furnaces for the more refined treatment of metals, such as the open hearth steel and copper refining furnaces, exact specifications should be enforced, limiting the ash to 3 or 4 per cent. Copper matte furnaces producing less refined copper than the above will stand a high percentage of ash. This ash, if deposited on the charge, is drawn off with the other slagged impurities. The one essential of coal for powdered coal burning is high volatile content. This should be above 20 per cent.—William A. Evans.

The type of furnace is the deciding factor in the choice of the coal. Following are two analyses which have given very satisfactory results in open hearth practice:

	No. 1	No. 2
Ash	10	5
Sulphur	1	½
Volatile matter	37	unknown
Moisture	1½	1
Cost per ton delivered	$2.50	$3.35

The following coal has been used for a period of about 10 years for heating annealing ovens:

Ash	19.05
Sulphur	3.53
Volatile matter	24.62
B.t.u.	11,000

This coal was obtained for $1.70 delivered. Comparison of the above analyses will show the fallacy of predicting just what grades of coal can, and cannot, be burned. The consumer will have to decide for himself what coal will give the highest economy, and can probably arrive at no conclusion without actual tests. One user of the coal given in the second analysis has, after a period of 10 years of success with it, decided to change to a coal containing a much lower percentage of ash, and consequently higher calorific value. The reasons given are, less accumulation of ash in the furnace, and therefore the elimination of much of the expense of handling it, through the saving of the cost of pulverizing and otherwise preparing the useless ash, and that due to the higher calorific value of the fuel. This would seem to indicate that a more expensive coal containing less ash and having higher calorific value will decrease annealing costs; just how far this theory can be carried into actual practice depends on the local plant conditions and can probably be determined only by experiment.—A. W. Raymond.

(2) *Experiences with Coal High in Ash and Sulphur.*

The amount of sulphur present in coal used for reverberatory smelting is of little or no importance as the charge to the furnace always contains a large amount of sulphur. The ash, however, is of great importance. At different times we have used coal containing from 5 per cent to 10 per cent ash. When the coal is burned, part of the ash sticks at the throat of the furnace in a pasty condition, and when there is as much as 10 per cent ash, it tends to build up here and eventually interferes with the smelting. Usually, however, it can be kept barred off without much difficulty.

Another portion settles in a fine pulverulent condition in the flue chamber beyond the throat. This simply requires drawing out periodically with hoes through small side doors built in for that purpose. The amount obtained when burning about 70 tons of coal per 24 hours is 400 or 500 lb.

The greatest portion of the ash, however, settles on the bath in the furnace and forms part of the liquid slag. It is drawn off in that form and of course causes no difficulty whatever, only increasing somewhat the amount handled.

As coal ash is high in silica it is quite evident that a basic slag will combine with it most readily and in such a case the ash might be valuable as a flux. On the other hand, an addition of this high silica ash to a slag already high in silica might easily raise the melting point sufficiently to cause a good deal of trouble and interfere seriously with the working of the furnace.—J. L. Agnew.

We find the ash rather troublesome, but this would not have been enough to condemn the coal had the price been low enough to warrant some extra trouble. In trying a gas slack of 12 per cent ash and 2 per cent to 3 per cent sulphur, we found trouble with both the ash and the sulphur, the latter throwing off very disagreeable fumes in the plant.—W. P. Barba.

Coals running as high as 25 per cent ash, 5 per cent sulphur, have been used with success in cement manufacture.—H. G. Barnhurst.

The higher the percentage of volatile matter, the better the results obtained. In metallurgical furnaces the percentage of ash and sulphur should always be kept as low as possible, although the sulphur in the coal does not appear to be absorbed by the iron to any great extent; no more so than in the regular hand-fired puddle and heating furnaces. The ash causes very little trouble in furnaces maintaining a temperature of 2500 deg. fahr. or over, and in puddle and heating furnaces, having waste heat boilers located above them, part of the ash is deposited in the combustion chamber, part in the furnace proper, while the remainder is deposited beneath the boilers.

Very little ash passes up the stack. The ash deposited in the combustion chamber is removed by dropping the bottom or through the combustion chamber door. The bottom is made up of easily removable grate bars, upon which rests a layer of fine ash, which together with the furnace brick forms a pasty slag. This slag becomes hard and brittle when cool.

It is possible to remove this pasty slag through the combustion chamber door several times a day without difficulty and to clean this chamber entirely once a week, by pulling out the grate bars. The ash which is carried over the bridge wall runs off with the slag and the remainder of the ash is deposited under the boiler and removed at the end of each week.—John V. Culliney.

In the cement industry, a coal high in ash may increase the formation of clinkers, particularly if the raw materials fed to the kiln are deficient in silica. Otherwise, a coal having a high percentage of ash causes only a slight inconvenience, due to the removal of larger quantities of fine ash from the dust settling chambers. In some cases where the ash has a low fusing temperature, trouble may be caused by the formation of an excessive amount of slag. Generally the presence of sulphur in large or small percentages is the cause of a great many difficulties.

Where the coal is used in drying furnaces, such as rotary dryers, the presence of sulphur in the coal will cause no ill effects, but where powdered coal is used to reduce nickel ores, copper ores, etc., especially in the refining end of the industry, the question of sulphur in the coal should receive careful attention. It has been claimed that if the sulphur in the coal is first burned off to the dioxide form SO_2, there is very little danger of it combining with a molten mass of metal having a strong affinity for sulphur. If, on the other hand, the powdered coal is not supplied with the requisite amount of air causing incomplete combustion and burning the sulphur to the monoxide form SO, there is a great tendency of the sulphur to unite with the molten metal, particularly so because it is present in an atmosphere of CO and free carbon, and has no chance to take on more oxygen. I believe that even where there is great danger of sulphur absorption, a furnace can be constructed so that little or no sulphur in the coal will unite with the metal in the furnace, that is, the sulphur will be burned to sulphur dioxide and there will be an oxidizing rather than a reducing flame.—W. R. Dunn.

High ash coal often introduces insurmountable difficulties. The ash accumulates so rapidly in the combustion chamber and clings so tenaciously to the walls that it is almost impossible to remove it.—W. A. Evans.

The presence of sulphur in the coal is important only as it affects the material treated in the furnace. In this case a coal of low enough sulphur content must be used to keep the sulphur content in the finished product below the maximum allowed by specification. The relation of the sulphur content in the finished product to that in the fuel is about the same in the case of pulverized coal as of producer gas.—A. W. Raymond.

(3) *Essentials of Storage Bin for Powdered Fuel—Troubles from Storage.*

Our storage bins hold about 60 tons of powdered coal and are kept practically full all the time. The dust will take fire very easily, even a lighted match often being enough to ignite it, but it simply smolders away harmlessly. The best way in such a case is to shut off the supply of fresh coal and use up what is already in the bin.—J. L. Agnew.

The sides of the storage bins should be of very sharp slope in order to have the coal flow freely. It has been apparent that more clogging takes place if the moisture is allowed to go over 1 per cent than if it is kept below. Probably the interior smoothness of the bins has much to do with the coal flowing down as required. A great deal of moisture will form in the first bin in which the coal is stored after drying, if the time of storage is long, the moisture often running down through the coal and dripping out at the bottom of the bin. In the bin where the pulverized coal is stored we have found by experience that by the end of 96 hours combustion is likely to take place; and also that such has occurred in several cases in less than that length of time.—W. P. Barba.

It is advisable, in storing large piles of coal, to have the coal under roof, with at least two sides of the building open, in order to allow part of the moisture to evaporate, thereby lessening the work of the dryer.

Pulverized coal which is damp should never be stored for any great length of time, as spontaneous combustion is likely to occur. Dry coal can, however, be stored indefinitely.

All hoppers to hold pulverized coal should be made with two sides vertical and the other two sloped, at an angle of about 30 deg. with the vertical. This is done to prevent the coal from arching. The greater the percentage of moisture in the coal, the greater the tendency to arch.—John V. Culliney.

A good storage bin for powdered coal should be free from pockets or corners where the coal is likely to lodge and remain stored for some time. Powdered coal stored for some length of time is apt to ignite, due to spontaneous action. The bin should be of ample capacity, not too large, and should hold coal sufficient for 12 to 18 hours' use. It should be covered with a sheet iron cover to protect the feeding mechanism against foreign matter falling into the bin and getting into the working parts of the feeder; a cover also prevents the accidental introduction of sparks or fire. It should by all means be constructed of fire resisting material. Sheet iron bins are very serviceable, especially when the coal stored is in a dry condition and not allowed to absorb moisture from the air. Wet coal, if it contains a large amount of sulphur, generally causes rapid corrosion of the sheet metal plates. Dry powdered coal is exceedingly hygroscopic and it is necessary that the coal in the bin should be kept as free as possible from contact with the atmosphere of the room.—W. R. Dunn.

The bin should be of a size to carry over 14 or 16 hours without refilling, thus giving plenty of time for such repairs as may be required without shutting down the furnace. It also permits of operation of grinding plant during the day, giving enough storage to carry through night service. The only trouble that can come from storage of powdered coal is spontaneous combustion, when coal is allowed to stand too long in bins. Powdered coal should always be kept moving, not allowed to stand more than one day in case of a temporary shut-down of plant. For any greater length of time, the powder should all be drawn out of the bins. Spontaneous combustion is more likely to take place with powdered coal than with ordinary slack because of the heat accumulated during the grinding.—William A. Evans.

The essentials are proper capacity and shape of bin. The capacity should be large enough to permit of sufficient coal storage to carry the furnace operation through any shut-down which may occur in the grinding room. With the proper equipment a 24 hour storage is generally sufficient and absolutely safe. Pulverized coal when properly prepared has been stored without any occurrence of fire for periods of from a week to ten days. Storage for such a long time as this can only be accomplished without fire danger if the coal is delivered to the bins in a thoroughly dry condition and at a comparatively low temperature.

The bins should be made and kept as airtight as possible. A very frequent difficulty experienced in the storage bin is a tendency for powdered coal to bridge over at the bin outlet, and consequently stop flowing into the feeder. Such a condition is sometimes very hard to overcome. One very large and successful user of the fuel claims to have eliminated this annoyance by a peculiar construction of the bin. The ordinary cone shaped hopper is replaced by a trough of triangular cross-section and a small conveyor is run directly through the coal along the bottom of the trough. This conveyor can replace the one generally used to control the amount of coal fed to the furnace, and the equipment consequently becomes as simple and inexpensive as the one previously used.—A. W. Raymond.

(4) *Necessity for Drying Coal before Grinding.*

Coal as received runs from 4 per cent to 8 per cent moisture, which should if possible be reduced to 1 per cent or less. This is not an easy matter. A small lump of coal may be ignited on the surface and still not be dry throughout. Moisture is detrimental because (*a*) it reduces the capacity of the grinders, (*b*) it tends to pack in the storage bins, (*c*) it lowers the possible attainable temperature, and (*d*) it lessens the efficiency.—J. L. Agnew.

It is essential to have the coal dried to at least 1 per cent of moisture, both for the ease of pulverizing as well as for ease of screening in the pulverizer.—W. P. Barba.

Where high temperatures are required, a higher degree can be obtained by the use of dried rather than wet coal, as the temperature of combustion will decrease with the increased percentage of moisture. For instance, a coal containing 3 per cent moisture, as it frequently does, if passed through a drier would give approximately a temperature of 3200 deg. fahr. when burned with 25 per cent excess air, whereas the same coal containing 10 per cent moisture would give only 3000 deg. when burned with 25 per cent excess air. In ad-

dition to the above, wet coal clogs the screens of certain types of pulverizers considerably, decreasing the output of the pulverizers and also affecting its quality. Wet coal will stick in bins and in burners.

Coal should be dried to 1 per cent or less before pulverizing, if possible.—H. G. Barnhurst.

If it is desired to obtain conditions such that the coal will ignite instantly, the moisture content should not exceed one-half of 1 per cent. The coal on its way to the furnace, after it has been dried, absorbs additional moisture, and by the time it is ready to be used it may contain as much as 0.7 of the 1 per cent moisture. Dry coal is desired because it can be more intimately mixed with the air and fed more regularly to the furnace. Wet coal or damp coal will clog the feeding mechanism and ejector tubes, and in addition to this, it is apt to form coke in the furnace and the furnace temperature will not be so high as when dry coal is used.—W. R. Dunn.

The necessity for drying coal is controlled by two factors, the design of the grinding machine and the capacity of the plant. The first factor concerns machines that depend upon screens for regulating the fineness of the coal. Where screens are used coal must be dried. With moist coal screens clog up. Machines that depend upon air separation for regulating the fineness of coal have no such difficulty. They do, however, consume more power when grinding moist coal.

The other factor, viz. capacity of plant, is important as it has also to do with economy in building a small plant. Where but 20 or 30 tons a day are to be used it is possible so to select coal as to keep its moisture down to under 5 per cent. This can be secured by shipping in boxed cars and carrying in dry storage a sufficient quantity to last ten days or two weeks. Where large quantities are used and where it is impossible to carry enough storage to insure a continuous supply of commercially dry coal a dryer is absolutely necessary.

It will be argued that there are plants using coal that has not been dried. Where this is done in large quantities it will be found that the same plant has other furnaces or other means of using up the wet coal that comes to the plant and is able to select the driest for use in the machines in question. The writer has used coal containing 20 per cent moisture. Although it is possible to struggle through for a short time under this condition, it is so troublesome that it can be put down as a good rule as not possible. Wherever undried coal is used it is in the direct delivery system, where the coal is fired direct from the pulverizer to the furnace. The storage system will not work on moist coal; caking and arching of the coal in the bins interrupts the uniformity of feed.—W. A. Evans.

Burning wet coal introduces moisture or steam into the furnace, where its presence is always sure to prove a hindrance to efficient combustion, and consequently prevent the attainment of highest economy.

Coal containing more than 1½ per cent of free moisture will require more horsepower when being pulverized, and the pulverized product will contain a much lower percentage of impalpable powder. Therefore, it is axiomatic to say that drying the coal will prove economical.—A. W. Raymond.

(5) *Fineness of Grinding.*

The finer the coal is ground the more complete will be the combustion. The standard practice of 95 per cent to pass through a 100-mesh screen, and 80 to 85 per cent to pass through a 200-mesh screen is good practice, and one to which we endeavor to adhere.—W. P. Barba.

It is customary in the cement industry to grind coal to such a degree of fineness that 95 per cent will pass through a 100-mesh screen. The finer the coal the greater its moisture absorbing properties. Fine coal is also more liable to spontaneous action than the same coal more coarsely ground. —W. R. Dunn.

Standard practice was for some time to attain a fineness such that 90 per cent would pass through a 100-mesh screen. This has gradually been increased to a present standard of 95 per cent through a 100-mesh screen; with 80 per cent passing a 200-mesh screen. Finer grinding would be very desirable except for the much increased cost for power.—W. A. Evans.

It is generally accepted that coal which contains less than 95 per cent of material which will pass a 100-mesh test sieve and less than 82 per cent which will pass a 200-mesh sieve cannot be burned with the highest efficiency of combustion and the greatest economy. In direct contradiction to this is the experience of one of the oldest users of the fuel in annealing ovens. In this particular case the coal is pulverized so that only 60 per cent will pass a 100-mesh sieve and only 37 per cent will pass a 200-mesh sieve.

It is futile to expect a decrease in the cost of fuel by pulverizing coarser than 95 per cent through the 100-mesh sieve. I think it will be agreed that coal must contain no particles which will not pass through a 40-mesh sieve, and when this requirement is met there will always be at least 95 per cent of 100-mesh goods in the finished product. Consequently an attempt to pulverize coal so that it will all pass a 40-mesh sieve and, at the same time, contain less than 95 per cent which will pass a 100-mesh sieve, means the addition of special machinery whose maintenance cost is high and there is therefore no gain in economy in the preparation of the coal. As we cannot reasonably expect a coarse degree of pulverization to show any added efficiency in the furnace over a finer degree, there is no hope of obtaining higher economies by pulverizing coarser than 95 per cent through a 100-mesh. In fact, if the proper equipment is used it will be found less expensive to produce a coal containing 95 per cent of 100-mesh goods and from 82 to 85 per cent of 200-mesh goods, than that of any other fineness.

As for coal of a higher degree of fineness, we can undoubtedly expect a higher efficiency of combustion and there will also be less annoyance from the ash, due to the fact that it is in a more finely divided state. To offset this, on the other hand, there is the added cost of preparation.

I believe the only way the question can be answered satisfactorily is by experiments with coals of various finenesses. From my knowledge of pulverizing costs I can say that the degree of pulverization can be absolutely limited to 98 per cent through the 200-mesh. This degree can be attained with a comparatively small increase in preparation, but to go further increases the cost excessively. All that we know at present are the limits of the field in which to investigate,

viz: the coal must contain not less than 95 per cent through the 100-mesh and not more than 98 per cent through the 200-mesh.—A. W. RAYMOND.

(6) *Cost of Grinding and Handling, including Upkeep.*

The average cost of grinding and delivering the coal to the furnaces is about 45 cents per ton, and is made up as follows:

	Cents
Labor	15
Power	10
Repairs	14.5
Coal for drying	5.5
	45.0

These figures represent an average for 5 months from April to August, 1913.

The item "repairs" includes all repairs to coal crackers, grinders, conveyors, fans, belting, etc. Three men on one 10-hour shift are all that are necessary to prepare and deliver 70 or 80 tons to the furnace per day.—J. L. AGNEW.

The cost depends largely upon the amount of coal operated upon. Based on 200 tons in 24 hours, with coal at $1 per ton and same coal being used for power, the expense would be, fuel for drying the coal, power, labor, supplies and repairs, approximately 17.6 cents per ton; at $2, about 21.8 cents per ton; at $3, about 23.9 cents per ton. These figures, however, do not include overhead charges, interest or depreciation—in other words, the cost of preparing depends upon the quantity to be pulverized, as well as cost of labor, power, etc., entering into the operation. Repairs to driers and mills should not exceed 2 cents per ton, and the power required for this operation should not exceed 17-h.p-hr. per ton.—H. G. BARNHURST.

In a mill having an average output of 150 tons per day, the cost is about 40 cents per ton.—JOHN V. CULLINEY.

The figures given herewith are taken from a plant capable of grinding 140 tons of coal per 24 hours. As the plant was built about 16 years ago, it contains more refinements and larger storage space than is considered good practice to-day. The average cost per ton of 2000 lb. for pulverizing coal (including interest on investment, 5 per cent for depreciation and 5 per cent for obsolescence) is:

	Cents
Labor operating department	15.64
Labor repairs to machinery	1.70
Supplies, fuel, power, etc.	14.71
Oils and waste	1.25
Repairs	4.54
	37.84
Interest, depreciation and obsolescence	1.35
Total	39.19

—W. R. DUNN.

The cost is very well established to be between 40 and 45 cents per ton, which, when replacing mine run coal, is just about taken care of by the possible use of slack coal at 50 cents per ton less than what the mine run costs.—W. A. EVANS.

The cost will vary with the local plant conditions, the variable factor being, of course, the cost of handling. The pulverizing cost naturally depends upon the degree of pulverization, and the amount of coal consumed. Table 1 will give some idea of how this cost varies, and form a basis on which to calculate this cost for any particular installation. The figures are applicable only when the Raymond system

TABLE 1 COST FOR PULVERIZING COAL

Capacity of Grinding Room, Tons per Hour	Percentage through 100 Mesh	Percentage through 200 Mesh	H.P. at ¾c. Kw-Hr.			Labor		Cost per Ton for Maintenance	Total Cost per Ton
			Total H.p. Required	Hours per Ton	Cost per Ton	Men at $2 per Day	Cost per Ton		
1	99	95	45	45.0	22.5	1	20.0	6.66	49.16
2	95	82	45	22.5	11.25	1	10.0	3.33	24.58
2	99	95	60	30.0	15.0	1	10.0	3.40	28.40
3	95	82	60	20.0	10.0	1	6.66	2.22	20.88
3	99	95	85	28.0	14.0	1	6.66	2.40	23.06
4	95	82	75	19.0	9.5	1	5.0	1.70	16.20
5	95	82	85	17.0	8.5	1	4.0	1.20	13.70
6	99	95	170	28.0	14.0	1	3.33	2.40	19.73
10	95	82	170	17.0	8.5	1	2.0	1.20	11.70
10	99	95	255	28.0	14.0	2	4.0	2.40	20.40
25	95	82	425	17.0	8.5	2	1.7	1.20	11.40
25	99	95	680	28.0	14.0	3	2.4	2.40	18.80

of pulverizing is used, and are obtained from actual experience covering a period of over five years. Table 2, from the

TABLE 2 FUEL REQUIRED TO DRY COAL

Percentage of Moisture in Coal	Coal Consumed per Hr. in Lb. in Operating Dryer *					
	160	230	350	540	715	900
	Capacity of Drier in Tons per Hr.					
1	19.5	28.1	43.2	66.8	88.9	113.0
2	15.3	25.1	33.5	51.8	68.9	86.3
3	12.7	18.2	27.5	42.4	56.4	70.6
4	10.7	15.5	23.6	36.4	48.4	60.6
5	9.3	13.3	20.3	31.3	41.6	52.2
6	8.1	11.7	17.7	27.4	36.4	45.7
7	7.2	10.4	15.7	24.1	32.1	40.2
8	6.5	9.4	14.3	22.0	29.3	36.7
9	5.9	8.5	12.8	19.8	26.4	33.0
10	5.4	7.8	11.8	18.4	24.4	30.4
11	5.0	7.1	10.8	16.7	22.2	27.8
12	4.6	6.6	10.0	15.3	20.2	25.2
13	4.2	6.1	9.3	14.4	18.9	24.0
14	3.9	5.7	8.6	13.3	17.7	21.9
15	3.7	5.3	8.0	12.3	16.3	20.2

* Coal to have 14,000 B.t.u. per lb.

Ruggles-Coles Engineering Company, will be of service in calculating drying costs.—A. W. RAYMOND.

(7) *Danger from Particles of Dust Floating in Air.*

The grinders, conveyors and bins are all enclosed and very little dust escapes. We have used open fires continuously in the building where the grinding is done and never have had an explosion or an accident of any kind due to dust in the atmosphere.—J. L. AGNEW.

There is a real danger from dust and particles of powdered coal suspended in the air. Consequently, we have the building in which the pulverizing is done largely open at the bottom and open louvers at the top. Also we make

it a practice to keep the plant clean and free from accumulations of loose dust.—W. P. Barba.

Only when floating or mixed with air will pulverized coal puff or explode, if ignited. Explode, however, is too strong a term to use unless large quantities are involved, in which case the progressive rise in temperature and heat during the puff might increase the violence to an explosive degree. Coal being carried from pulverizers to bins should be handled as a solid material, and not in the shape of a dust cloud, since any firing would engage the whole volume. Aerial propulsion for transfer of pulverized coal should be avoided. Leakage should be guarded against to prevent dirt or accumulations in inaccessible places. Explosions occur only when the mixture of air suffices to supply oxygen enough to support combustion. A pulverized coal plant should be kept clean, and it can be. Accumulations of dust on beams or projections when dislodged may in theory make an explosive mixture with the air, but such explosions are rare. Explosion is only combustion intensified. It is only through carelessness that any explosion in the handling of pulverized coal could occur to-day.—H. G. Barnhurst.

Coal dust is dangerous only in a suspended state, that is, surrounded by sufficient air to cause instant deflagration. Many pulverized coal plants will be found that have coal dust floating around in the air, surrounding the pulverizing machinery. There is, however, no excuse for this, since a pulverizing equipment may be compared to a steam plant. If a steam boiler can be kept from leaking under a pressure of 100 lb., surely a pulverizer can, in which there is practically no pressure.—John V. Culliney.

There is always danger of fire from particles of any kind of dust floating in air in a confined space if fire or sparks are allowed in that space. In the case of powdered coal there is no excuse for dust escaping except in the grinding room, which is bound to be somewhat dirty. The protection is to insist upon no sparks or fire in the grinding room. Danger is absolutely eliminated in the case of the direct delivery system, for there is then no powder escaping.—W. A. Evans.

Coal dust which is finer than 200 mesh may be considered extremely dangerous. Very finely divided particles are liable to ignite spontaneously. Coals which ignite below a temperature of 150 degrees within one hour are dangerous. The liability of coal dust to ignite spontaneously is dependent upon the temperature of self-ignition and the time of heating necessary, and increases in proportion to the percentage of oxygen present in the coal.

Coal dust which is suspended in air can be ignited without the presence of inflammable gas. The presence of moisture lessens the probability of explosion, and therefore dust should be dampened with sprinklers. The use of stone dust has been suggested for preventing explosions, but its value in that connection is doubtful.

Coal dust containing any uncombined hard material, like silica, is very dangerous to health, usually producing a fibroid condition of the lungs.

In plants where particles of dust are floating about in the air, it is advisable therefore to use the following precautions: (*a*) permit no smoking; (*b*) prohibit the use of matches; (*c*) do not use naked gas lights; (*d*) have no girders or open beams on which the coal dust may possibly lodge; (*e*) use only incandescent electric lamps for lighting; (*f*) be sure that all machinery, floors and walls are kept clean; (*g*) prevent the escape of dust by providing a short and direct discharge to the furnace.—Edward J. Kelley.

When the atmosphere in the grinding room becomes impregnated with coal dust, a condition exists which may result in a very serious explosion. This is, practically, the only danger which occurs in the handling of pulverized coal, and it is entirely eliminated by the use of equipment in which the coal can be prepared without allowing any dust to leak out and permeate the surrounding air in the room. —A. W. Raymond.

(8) *Essentials of a Good Burner.*

Only one type of burner (Fig. 1) has been used here. It has given no trouble. One essential of a good burner is that the air and coal supply must be under complete control.—J. L. Agnew.

The essentials are regular feed, ease and accuracy of control and regulation. If these requirements are complied with in any type of burner, it should be satisfactory.—W. P. Barba.

In a good burner there should be absolute control over the flow of pulverized coal to the burner pipe. In other words, it should be so devised that the clearance around the screw, or other means of transfer, should be small, so as to prevent any rush of coal by vacuum formed by blower in the burner pipe. Pulverized coal when mixed with air flows easily. There are a large number of so called burners on the market which are in reality fuel controllers, and do not have anything to do with the actual burning of the fuel. In other words, they feed the coal to the burner pipe only. In burning pulverized coal absolute control must be had for regulating the quantity of air for controlling the temperatures.—H. G. Barnhurst.

The essentials are: (*a*) uniform feed, (*b*) proper mixture of coal and air, (*c*) proper control; ability to vary coal supply, (*d*) simplicity, (*e*) compactness.—John V. Culliney.

A burner should thoroughly and intimately mix the coal dust and air. It should feed the coal with absolute uniformity to the furnace to which it is attached, and be so constructed that the air or blast pressure can be varied to suit the requirements. The feeding mechanism should respond instantly to the demands made upon it by the operator. All parts should be accessible and readily removed for renewals and repairs with very little inconvenience, and be so proportioned that the velocity of the coal leaving the burner is not excessive. It should be capable of burning coal to within one-half inch of the extreme burner tip, and so constructed that the tendency to choke up is reduced to a minimum. Should such choking occur, due to the accidental introduction of foreign matter, it should be so made that it can be readily cleaned.—W. R. Dunn.

The difficulties in the way of obtaining easily the essentials of uniform feed of both air and coal, thorough mixture of the

two, and exact control of both, have been the tendency of powdered coal to flush through any opening uncontrolled and also to cake and to arch over at the point of delivery from storage hopper.

There are two general types of powdered coal burners in use, those depending upon varying the speed of a screw conveyor for control, and upon varying the quantity of air blowing through a stream or small mass of coal. The control by air rather than that by screw conveyor of variable speed seems to work out to the best advantage, for the reason that any speed control is bound to be bungling and not of sufficiently fine adjustment. On the other hand, the quantity of powder picked up by a blast of air in passing through either a falling stream of coal or forcing its way through a small body of the powder has a constant ratio to the air blast and is subject to very exact control. A good burner should operate within 3 per cent variation in quantity of coal for any number of 5-minute intervals for any given setting of its controller. In the case of the air control the blast of air operating at about 6 oz. picks up more coal than it can furnish with oxygen, so additional air has to be provided for combustion. Two air blasts are therefore provided, one for control of the quantity of coal and for conveying the coal from the controller up to the furnace. The other air supply is for furnishing the additional amount of air for combustion, usually at about ½ oz. pressure.—W. A. Evans.

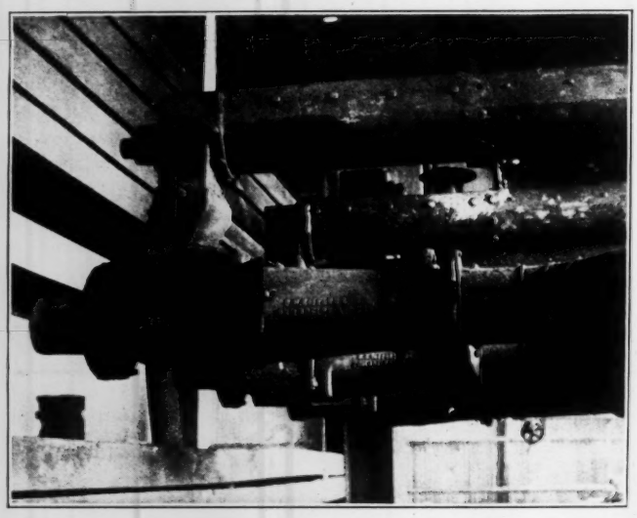


Fig. 1 Burner used in Metallurgical Furnace

The supply of coal should be absolutely under control, and the mixture of the coal in the air uniform. There are several burners on the market which very nearly approximate this result. They are either of the syphon type, in which the supply of coal is controlled by air suction, or the more common screw conveyor type, which depends on a variable speed screw for regulating the flow of the coal. One very good way to insure a uniform mixture of coal and air is to make the coal dust travel through a horizontal pipe at least 6 or 8 ft. long, after it is fed to the air and before entering the furnace. —A. W. Raymond.

(9) *What Troubles are Likely to Occur with Burners in General.*

Stoppage of the burner is the usual trouble, which may be caused by small foreign substances and occasionally by the powdered coal arching over in the bin, due possibly to dampness or other causes, and then falling with a sudden avalanche effect, which, in some cases, stops the burner or blows a fuse, and in other cases sends a heavy charge into the furnace and the powdered coal which cannot be burned forms a heavy smoke.—W. P. Barba.

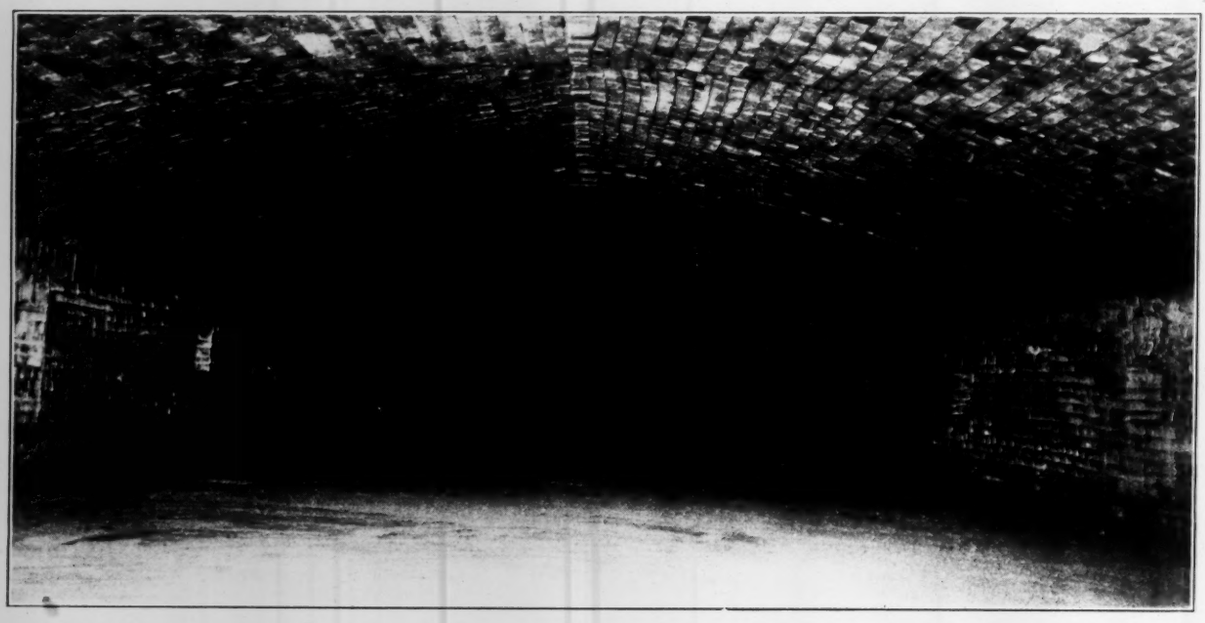


Fig. 2 Inside of Reverberatory Furnace, looking toward the end at which the Pulverized Coal is Introduced

No troubles should occur with burners of proper design, if the coal is thoroughly dried and properly pulverized.—H. G. Barnhurst.

The troubles found with most controllers are: (*a*) inability to mix coal and air properly, (*b*) irregular feed, (*c*) choking up, and (*d*) inability to control for small furnace use.—John V. Culliney.

Intermittent and non-uniformity of feed, choking up of air passages, the accumulation of foreign matter in the interior of the burner to high velocity through the discharge pipes, and unreliability of feeding device are troubles that may occur.—W. R. Dunn.

The troubles that can occur are interruptions from caking and arching over as previously spoken of and the flushing of coal through openings and along screw conveyors if used as part of the burner. Uniformity of feed is also possible of some improvement. These troubles are entirely overcome by the use of a direct delivery system where the control is all obtained, while the coal is still coarse and easily kept within control. Burners must be placed within 5 ft. of the furnace, for otherwise the coal will settle out from the air and the thorough mixture will be disturbed.—W. A. Evans.

(10) *Special Features Required in Powdered Fuel Furnace.*

No special features need be introduced in a reverberatory furnace to make it suitable for use with pulverized coal. All that is necessary is to omit the usual firebox entirely and extend the bridge wall to the roof. Holes of course will be left in the bridge wall for the burners to pass through. Fig. 2 shows the inside of a reverberatory furnace before being put into commission looking towards the end at which the pulverized coal is introduced.—J. L. Agnew.

A proper distance between the burner and a bridge wall must be designed so that combustion may take place, the

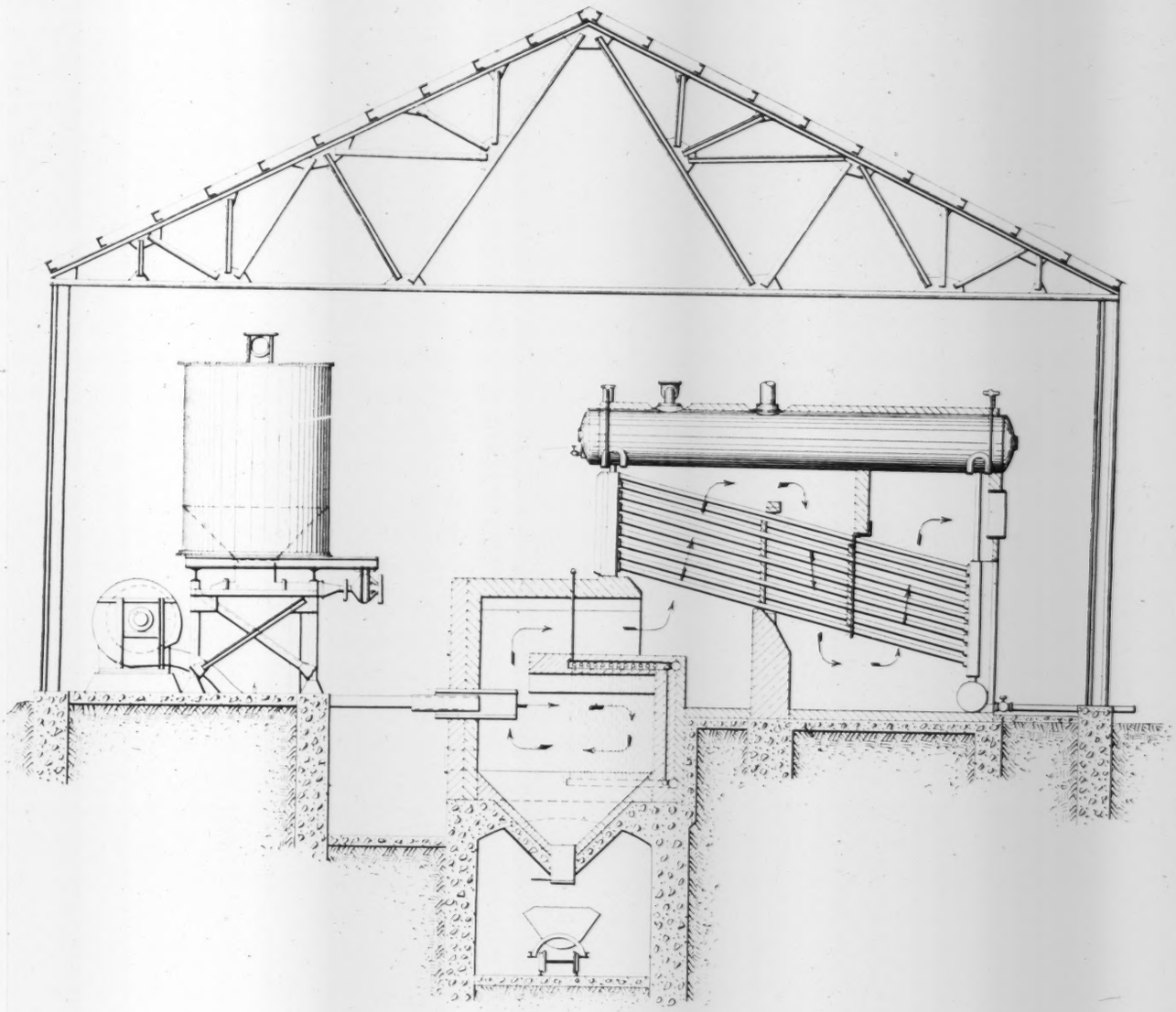


Fig. 3 Design of Furnace for Burning Low-Volatile, High Fixed-Carbon Fuels

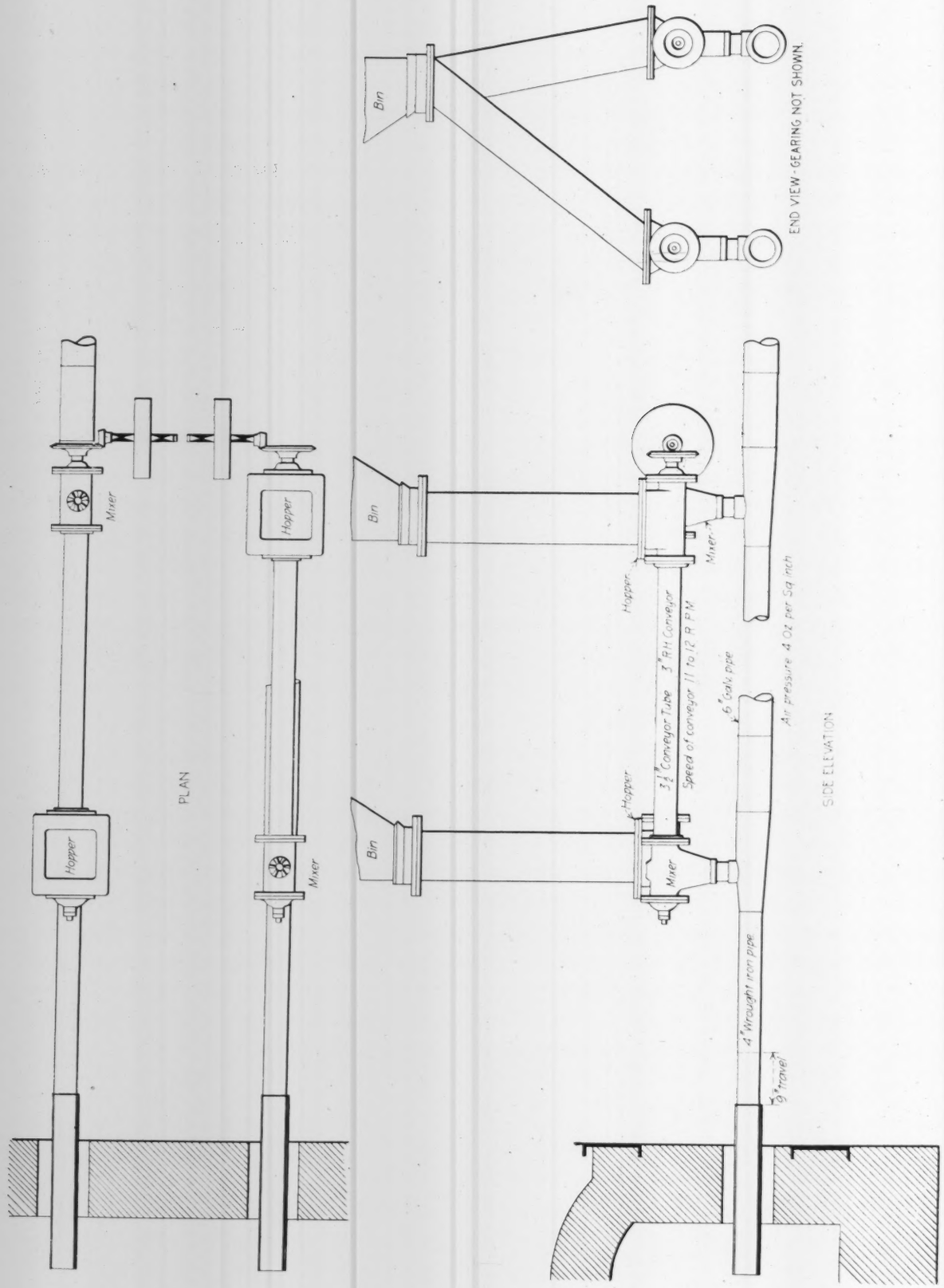


FIG. 4 DUNN SYSTEM FOR BURNING POWDERED FUEL

flame impinging upon the wall, causing a certain amount of the ash to settle and giving a proper distribution of heat on the hearth.—N. P. Barba.

Fig. 3 shows a design of a furnace for burning low volatile, high fixed carbon fuels, such as anthracite, coke breeze, etc. In these furnaces the blast passes down and up and over an arch, thereby surrounding the incoming fuel and supplying the heat necessary for the initial ignition. The main principle governing the design of a furnace for burning pulverized coal is that it must be sufficiently large so that coal when burned will have time to complete its combustion before leaving the furnace. In open hearth furnace practice the same condition exists as in rotary kilns, i.e., the fuel must be projected and burned directly over the bath. Furnaces to suit fuel requirements for any individual operation should be designed especially for the work in question.—H. G. Barnhurst.

In puddle, heating, forge and like furnaces the high pressure air blast should range between 4 and 6 oz., the

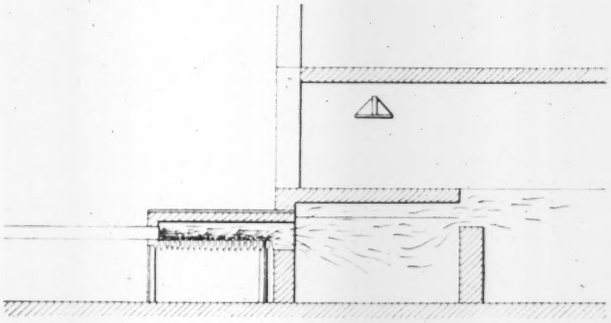


Fig. 5 Brick Arch used to Protect the Flame from the Chilling Effect of the Boiler Surface

low pressure or volume air blast from 1 to 2 oz. In all experimental cases with air blast it is always advisable to begin with too low a pressure and slightly increase it until proper pressure is reached, rather than to begin with a high pressure and work down.—John V. Culliney.

Fig. 4 shows a burner fitted to a reverberatory furnace. No change whatever was made in the furnace, which was formerly heated with oil. The burner tip is so constructed that it is readily adjustable. In starting the furnace, the burner tip is extended the full length and after ignition takes place it is gradually withdrawn so that it becomes flush with the inner wall.—W. R. Dunn.

(*Topics 10 and 12*) The essential features for furnaces for burning powdered fuel are emphasized in the almost complete failure to secure success under boilers. The essentials are temperature of at least 2000 deg. fahr. throughout the entire furnace and large combustion space, at least 1 cu. ft. for each 3 lb. of coal burned per hour. The boiler is essentially a low temperature furnace, seldom going over 1500 deg. fahr., and in no case does it offer sufficient space for combustion out of contact with the boiler surface. An idea of the space required under a water tube boiler running at modern high ratings is indicated in Fig. 4. This is almost prohibitive, at least for application to any existing plants. It would require a vertical height of 15 ft. below the tubes of a 600-h.p. boiler subject to peak loads of 1800 h.p. Horizontal return tubular boilers do not present the difficulty of space, for they are seldom run over rating, and are normally built with much larger combustion space throughout their entire length than is provided with any water tube boiler. They do, however, give difficulty from low tempera-

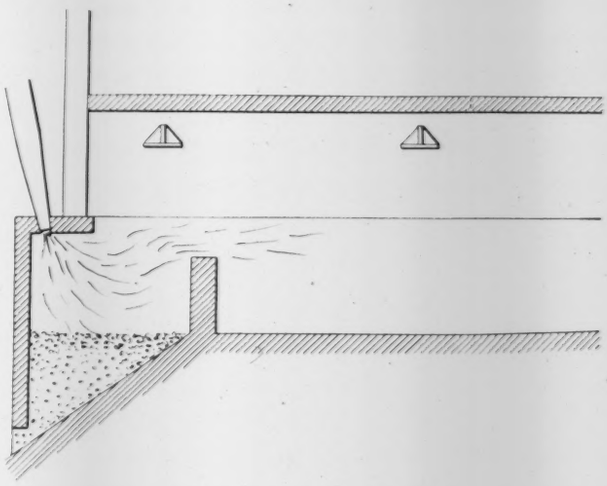


Fig 6 Design of Furnace with Bottom Side Slanting down towards the Front

ture. The writer has never been able to maintain combustion under a return tubular boiler except with the assistance of an auxiliary igniting flame, and after protecting the flame from the chilling effect of the boiler surface by a brick arch, run a considerable distance back, as shown in Fig. 5.

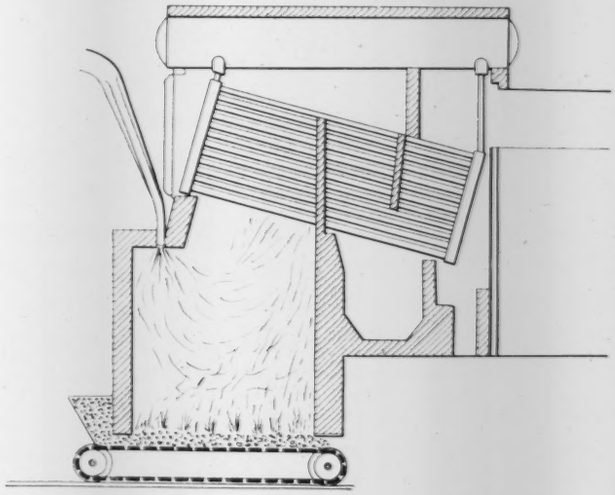


Fig. 7 Design of Furnace with Moving Side or Chain Grate

The auxiliary igniting flame was arranged as also shown in Fig. 5. It consisted of two 15-in. square steel boxes 5 ft. long, firebrick lined, leaving about 12 in. square inside, and with grate bars in the bottom. These were set directly in front of the two fire doors of the boiler. Coal fire carried on the grates provided the necessary igniting flame and was assisted by the close contact of the white-hot brick lining.

Aside from the difficulty of building combustion space large enough and of maintaining combustion, there is little

chance for powdered coal coming into general use on water tube boilers. The cost of grinding eats up any possible small advantage in economy it might have over the very efficient operation of mechanical stokers. The 95 to 97 per cent furnace efficiency of the latter leaves a very narrow margin for improvement; certainly not as much as 40 cents, the cost of grinding each ton of coal. That leaves the field for powdered fuel boiler firing possibly to horizontal return tubular boilers and to a few special conditions, such as waste fuel or a fuel that cannot be burned on stokers. The writer suggests a use that, to his knowledge, has not been tried. It is for peak loads. Powdered coal used only to supply the peak loads to heavily overloaded boilers would very much increase their capacity, would be in use only for short periods, would be entirely automatic, and might prove of untold values.

The writer's experience has been that wherever ash has a chance to deposit within the range of the flame slag will form and be of such a sticky, sluggish nature that it is next to impossible to remove it. It chills solid at 1800 deg., or as soon as any door is opened to break it out. It is suggested that a flux be used to make the slag more fluid, so as to allow it to be drawn off in its fluid state. The writer has never tried this.

A patent was recently issued to a Pittsburg concern involving the use of a furnace with its bottom side slanting down towards the front, as shown in Fig. 6. A narrow opening at the lower end is supposed to permit of drawing off ash at the same rate as it deposits on the top surface. This does, however, crust over on the top surface so that the slag does not settle down to the opening.

Another patent recently applied for involves the use of a moving side to a furnace such as a horizontal chain grate (Fig. 7), this grate to carry a bed of cinders or other protecting material, or even coal. Such a moving side or chain grate would continually remove the slag as fast as deposited, and the protecting material would form a very desirable indestructible impinging surface. This same arrangement with coal used on grate would permit of the coarser grinding of the powdered coal, allowing the coarse particles to drop to the grate, thus insuring complete combustion regardless of the coarser grinding.—W. A. Evans.

(11) *Air Pressure Used and Effect of Stack Draft on Combustion.*

Coal is blown into the furnace with air under 6 or 8 oz. pressure. This air supplies only a portion of the oxygen required for combustion, the balance being drawn into the furnace through openings around or near the burners. The amount of air drawn through these openings is dependent entirely on their area and the stack draft. The latter should be under control by means of a damper. The draft, at the throat of the furnace where the area is about 40 sq. ft., is usually between 1.0 and 1.2 in. of water.—J. L. Agnew.

The air for atomizing the powdered coal which we have used is under 4 to 6 oz. pressure, but we believe this to be higher than desirable. The air for combustion should be very low in volume. The stack apparently has little effect upon the combustion but is necessary to carry off ash and gases.—W. P. Barba.

In furnaces and in the pipes conveying the coal from the bins, there should be at all times a slight vacuum maintained so that leakage of any sort should be toward and not from the furnace. In other words stack draft should be sufficient to create a slight vacuum in furnace, and strong enough to take care of all the products of combustion.—H. G. Barnhurst.

It has been found advisable to place a damper on the top of the stack, keeping it almost closed during heating. With the damper in this position and the neck of the furnace as small as allowable, one obtains the best results with pulverized coal, both in the saving of coal and increase of furnace temperature and decrease of stack temperature.—John V. Culliney.

The air pressure generally used is 7 to 9 oz. per sq. in. The stack draft should be sufficient to carry off the products of combustion.—W. R. Dunn.

There is a great variance of opinion among the various users of powdered coal as to whether it should be fed into the furnace by air from an ordinary blower or by compressed air. There is no doubt that the use of a blast air increases the life of a furnace, as the flame does not seem to be quite so intense, and because of the lower velocity a more complete combustion is obtained in the combustion chamber. Those who uphold the use of compressed air say that it is necessary in order to obtain high temperatures.—A. W. Raymond.

(12) *Experiences with Ash or Slag in Furnace.*

The ash deposits largely in the combustion chamber, falling in front of the bridge wall as well as the hearth and tail of a continuous furnace. The slag is formed on the hearth which is removed by bars without a great deal of trouble. In the tail of the furnace the ash is soft and is usually pulled out with bent bars.—W. P. Barba.

The ash from the ordinary anthracite does not slag even though allowed to remain in the furnace for a considerable length of time. Soft coal ash, however, in most cases will settle down to the bottom of the furnace and if allowed to remain too long will slag. Most of the ash where pulverized coal is burned, passes out to the air above the chimney; what remains, if promptly removed, is easily cared for.—H. G. Barnhurst.

In regard to ash trouble, it might be said that only in furnaces operating at a temperature of 2000 deg. fahr. or less, is there any trouble of this kind. This difficulty is overcome by placing hoods over the door of the furnaces and connecting them to a suction fan which deposits the ash into a collector of the cyclone separator type.—John V. Culliney.

In the portland cement industry the formation of slag in the furnaces is unknown. The ash is generally collected in a dust chamber in the rear housing of the kiln.—W. R. Dunn.

(13) *What Temperatures are Maintained in Furnaces—Influence of Temperature on Formation of Slag.*

The working temperature of the furnace at its hottest part is about 2800 deg. fahr. This could be readily increased if desired, but the brickwork of the furnace would then suffer too severely. When working at the above temperature from 5 to 6 tons of material are smelted by 1 ton of coal. The kind of slag formed is determined by the nature

of the charge and should preferably run about 33 per cent to 35 per cent silica. Such a slag will flow from the furnace perfectly liquid at the prevailing temperature and also allow of a good separation from the matte.—J. L. Agnew.

Furnace temperatures can be controlled from 1800 to 3500 deg. fahr. If the air is preheated, there is no doubt but that considerably lower temperatures can be readily controlled, provided the temperature of furnace is above the kindling temperatures of the fuel. Slag is formed more easily with high temperatures than with low. Hence with thorough control of the burning mixture, serious results can be avoided. —H. G. Barnhurst.

The highest temperature in a rotary cement kiln is approximately 2600 deg. fahr. Temperatures high enough to melt nickel readily have been obtained with pulverized coal in reverberatory furnaces.—W. R. Dunn.

(14) *Experience with Checkerwork in Metallurgical Furnaces.*

None is used here, but the waste heat is utilized for generating steam in a boiler set in the flue. It is estimated that about 500 h.p. could be obtained in this way from the waste heat of one furnace when burning about 70 tons per day.—J. L. Agnew.

In regard to this item the only furnaces which we have had experience with, where checkerwork would enter into the construction, are those in connection with open-hearth furnaces, and it has been found that no serious trouble arose with the checkerwork or baffle walls. Checkerwork should be so designed that there is no horizontal or level places on which the ash could settle. We have not heard of any serious complaints with checkerwork—in fact, we know of one open-hearth furnace where 152 consecutive heats were obtained before furnace brick work necessitated shutting down for repairs, and there was no serious closing up of the checkerwork. The furnace brick work gave out before the checkerwork was choked up in any way.—H. G. Barnhurst.

In small singeing furnaces, a system of checkerwork acted as a bar to complete combustion and resulted in the formation of a considerable quantity of coke.—W. R. Dunn.

(15) *Life of Furnace as Compared with Furnaces using Other Fuels.*

The life of a reverberatory furnace is not adversely affected by the use of pulverized coal. As a matter of fact it is probably prolonged. On account of the uniformity of the heat, the contractions and expansions, which are unavoidable when grate firing is used, are done away with completely and consequently the furnace is much more likely to have a long life.—J. L. Agnew.

It is our opinion, without definite data to substantiate it, that the life of a furnace running with powdered coal is greater than that of a furnace using oil. We may safely say at least that the use of powdered coal does not appear noticeably to injure the furnace.—W. P. Barba.

The life of furnaces using pulverized coal naturally depends upon the type of furnace. Rotary kilns using pulverized coal, where the heat is being carried out with the outgoing clinker and is not cumulative in its effect, have linings which last from 8 months to 16 months; the lining, however, is subject to erosion by raw materials and clinker. The life of furnaces using pulverized coal is equal to that of hand-fired or oil-fired furnaces. With proper furnace control and using pulverized coal properly prepared the brick work should last just as long as when using any other kind of fuel.—H. G. Barnhurst.

The life of the furnace is about the same as the life of a furnace using fuel oil. I have known of cases where rotary kilns in the portland cement industry have retained their original lining for a period exceeding 26 months.—W. R. Dunn.

Pulverized coal furnaces operated at low air pressures will last longer than the ordinary hand-fired furnaces. By using too high air-pressure the bridge wall and roof of the furnace are destroyed and also the furnace waste is increased.—John V. Culliney.

(16) *Items of Expense or Economy in the Plant as a Whole, due to Use of Powdered Fuel.*

The main item of expense in the use of pulverized coal is the installation of the necessary plant for grinding the coal and distributing the dust to the points where it is to be burned. Next to this would come the power required and the repairs.

To offset these items of expense the labor required is less with dust firing than with the usual method. The latter would require at least double the number of men and the work would be of a much more trying kind. There would also be a considerable amount of ash and clinker to dispose of each day and an unavoidable loss of partly burned coal would occur in this material.

The great advantage, however, of pulverized coal firing is in the efficiency. The heat is uniform and under perfect control, the combustion is complete and takes place where it will do most good, but above all there is no delay for grating with an accompanying drop in temperature. The furnace is always working, and working at a uniform rate, both of which points are essential to efficiency.—J. L. Agnew.

Under the maximum production in a powdered coal installation it is probable that a good economy can be obtained. In our own case, on account of slackness in manufacture for which the powdered coal plant was installed, we have been unable to run economically or get any data on what we may expect under the best conditions.—W. P. Barba.

The economy of an installation for preparing pulverized coal as a fuel naturally depends upon the price of other fuels obtainable. The economy, however, obtained in the use of pulverized coal as against hand-fired furnaces in certain types of furnaces is remarkable.

In furnaces for heating billets, from 20 to 25 per cent has been saved; in open-hearth furnaces in comparison with producers, from 30 to 40 per cent; in puddling furnaces, from 33 to 50 per cent; in heating and bushelling furnaces, 20 to 25 per cent. These figures are authentic and can be verified. The principal items of expense are naturally the cost of preparing pulverized coal. The advisability of making a pulverized coal installation naturally depends on whether the saving obtained by increased efficiency of burning will overcome the additional cost of preparing the fuel. —H. G. Barnhurst.

The saving by the use of pulverized coal is made up largely of (*a*) practically perfect combustion, (*b*) no handling of coal or ash (*c*) no poking or clinkering, and (*d*) constant and uniform heat, resembling a gas fire and as easily controlled.

One other item which might be mentioned is the use of preheated air. By passing preheated air into a furnace at, say 600 deg. fahr., the number of B.t.u. required to heat this air, in the combustion chamber, from room temperature to 600 deg. fahr. is saved. The saving is not made up of this item alone but also by the increase of furnace efficiency. That is (*a*) more heats per hour, (*b*) higher furnace temperature, (*c*) uniform temperature, (*d*) less ash deposited on hearth of furnace.

In furnaces having waste heat horizontal boilers above them, wrought-iron pipes are placed in the boiler setting underneath the boiler. This robs the boiler of very little heat and at the same time causes a saving of about 15 per cent in the amount of coal used.

In small furnaces the pre-heated pipes are placed underneath hearth.

The American Iron & Steel Manufacturing Company have forging furnaces operated daily for the last nine years on pulverized coal. These furnaces range in size from 20 in. by 36 in. to 7 ft. by 16 ft., and are used for heating bolt, nut, spike and rivet bars and also for puddling, bushelling and heating. Drop forge for both small and large hammers.

Operating under normal conditions, we use about 260 tons (gross) of pulverized coal per day.—JOHN V. CULLINEY.

The chief item of economy in the use of powdered coal is the enormous saving effected as compared to the use of fuel oil. Another item of economy is the saving, due to a large elimination of labor expense.

Another great saving is effected, due to the perfect combustion of the coal. There are no unburned clinkers—the chief item of expense is the cost for power in grinding the coal.—W. R. DUNN.

DISCUSSION

A. G. CHRISTIE: Referring to the boiler shown in Fig. 8, I was in England about four years ago and had the pleasure of seeing one of the first units of this type in operation. During a visit there last year I went out again to see the same plant, and they reported quite favorably on the installation. It was the works of the makers themselves, where the boiler had been in practically continuous service under ordinary operating conditions in connection with their plant, supplying steam to the engines of their plant and also for their test floor.

While at the plant I asked the fireman to shovel out some of the ash which was dripping down into the ash pit and I brought some of it away as an exhibit to those here who would be interested in that boiler. The ash comes down as a slag from the brick and is shoveled out in the form of small drippings from the lining of the furnace. It does not seem to form any solid mass, and is easily broken up with a shovel. The operators reported very favorably in regard to operation and economy. It required very little care to keep the plant in operation and very little attendance from the fireman.

These boilers are used quite largely in South Africa, where they have a coal which dusts badly after it is mined. Many of the coals in the Canadian West have the same characteristics. They are not coking coals and disintegrate as soon as they are exposed to the air, due largely to the heavy rock pressure to which they have been subjected. It may be that this boiler will be applicable to that type of coal, i.e., one which does not coke and which powders badly on exposure to air.

GEORGE E. PFISTERER: I have had some experience in the use of oil to take care of peak loads for central station work. Peak loads are, as is well known, not like normal loads, and it is often very hard to handle them, particularly when a certain equipment is more or less limited in capacity. A peak load is the source of high maintenance cost because of the extra boiler equipment necessary, and also high operating cost because of the banked fires which have to be maintained. It is easily the hardest part of your boiler room work to handle, and it might be possible, under certain conditions, that pulverized fuel will be able to take care of these peak loads without extra boiler equipment, or without loss of coal due to banking.

The use of powdered coal is, I believe, more or less an experiment; there have been only about ten or twelve cases in which pulverized coal experiments have been tried out, and in most all of these cases, the relative efficiency, as compared to the best modern boiler practice, has only been increased 10 per cent gross, or a net increase of 15 per cent. The other points, however, in regard to maintenance, adaptability and convenience of powdered fuel, do not recommend it for every condition, and consequently stokers will probably maintain the place they have always held. For peak loads, it might be possible to utilize powdered fuel to tide over for a couple of hours, and the extra cost of equipment might be low as compared to the reduced fuel cost that might result while taking care of these peak loads. If we could get a stoker which would run continuously for 24 hours at a uniform rate, and would not have to be handled or disturbed, we could increase the efficiency to a considerable extent, probably 3 or 4 per cent, and if we could use pulverized fuel to tide us over peak loads, it might be possible to reduce the coal cost per kw. hour very considerably.

Powdered fuel in connection with locomotives has been practically untried. I know of one case where it was tried, but was very soon abandoned, the results obtained being not worthy of any further expenditure of money. The greatest trouble was that the grates would become clogged in a very short space of time, so that the feeding of coal had to be discontinued, and the steam pressure would consequently drop.

L. E. OSBORNE: As a large number of the members attending the Spring Meeting observed the working of the Street locomotive stoker on Burlington locomotive No. 6001 at Grand Crossing, Wis., I wish to suggest that with this stoker firing coal containing a considerable percentage of fine coal and coal dust, we have a condition to some extent similar to the burning of powdered fuel. As was seen, this machine blows the coal over the grate area with three jets. The very finest coal is burned in suspension and does not reach the grates. This stoker can successfully fire coals containing a large percentage of very fine coal and which cannot be successfully fired with the shovel.

CHAS. WHITING BAKER: This discussion on burning powdered coal throws light on the question, once much discussed in technical literature, as to whether the presence of water vapor in a boiler furnace, such as is furnished, for instance, by a steam jet blower, adds to or detracts from the efficiency of the furnace. The weight of scientific opinion has always been that the admission of water to the furnace, whether as moisture in the coal as steam from a blower, or otherwise, is detrimental to efficiency. It has been claimed, however, that where the water was admitted in such a way as to be decomposed to form water gas, which was later burned to CO_2, a more complete combustion of the coal was attained and there was less loss due to incomplete combustion.

The universal testimony in these papers and discussions, however, is that with powdered coal the moisture in the coal must be reduced to the lowest point to facilitate the distribution of the dust by the blast, and further, that this dried coal burns perfectly to CO_2, notwithstanding the absence of moisture.

LOREN L. HEBBERD (written): It has been brought out in the paper on Pulverized Coal for Steam Making, that the most important features or difficulties encountered are the disposal of incombustibles and the maintenance of the furnace. When these troubles are sidestepped by the use of excess air other serious faults are introduced; first, the incombustible in the form of dust is either deposited through the boiler passes or is carried out the stack; second, the efficiency and capacity suffers to such an extent that the system may become an economic failure.

It would therefore seem that the trend of experimentation should be to develop a furnace and a refractory material to withstand the heat. Under such conditions the ash would be slagged and the design must necessarily provide for its frequent removal. When these conditions are satisfied then high capacity and efficiency will necessarily follow. No doubt past investigators have satisfied themselves that this is impossible, but that does not prove that it will not be accomplished.

Of the various types of apparatus described in this paper it would appear that the Bettington boiler is a big step in the right direction and will lead eventually to successful results.

J. G. COUTANT: The American Iron & Steel Mfg. Co. have a dust collecting system installed in connection with all small furnaces, which embraces hoods over all furnaces so arranged as to collect all dust and gases issuing from the front of the furnaces over the work. The hoods are all connected with a heavy galvanized iron pipe through which the gases and dust are exhausted by a steel plate fan which discharges into a cyclone type dust collector. The gases suddenly admitted into the enlarged area lose most of their velocity and escape through an opening in the top to a stack; while the heavier dust and ash matter falls through the discharge orifice into a bin. With this system gases of 500 deg. to 600 deg. Fahr. are handled at 3 oz. vacuum and about 500 lb. of ash collected daily.

CHAS. J. DAVIDSON: It has occurred to me that in attempting to make the use of powdered fuel general, particularly in boiler furnaces, there is a serious obstacle, which apparently has not received serious consideration. I refer to the ash in finely divided particles, which is carried up the stack with the products combustion, and thereafter falls on the roofs or surrounding buildings and other objects which are exposed, and in the streets. In cement mills, lime kilns, etc., this probably is not a serious consideration. But, should an attempt be made to use this form of fuel in cities, while there might be no visible smoke, the residue referred to is, generally speaking, much more objectionable than smoke co-called, and might become a great nuisance and be legally prohibited. I would appreciate it very much if those who have had experience along this line would elucidate their ideas relative to this detail of the subject.

NECROLOGY

CHARLES HAZELTINE BASSHOR

Charles Hazeltine Basshor was born in Baltimore, Md., May 30, 1871, and died at his home near Cambridge, Md., August 22, 1914. He was educated at private schools in Baltimore. His shop experience and apprenticeship was served under his father, Thomas C. Basshor. Upon his father's death he succeeded him as head of the Thomas C. Basshor Company of Baltimore, and continued the business until about two years ago, when he retired.

Mr. Basshor was a member of the Engineers' Club of New York, the Maryland Club, the Kennels, the Green Spring Hunt Club, the Baltimore Country Club, and the Cambridge Yacht Club.

QUIMBY N. EVANS

Quimby N. Evans was born August 15, 1845, at Lovell, Me., and had a common school education at Freyburg, Mass. He served an apprenticeship with the Pitkin Brothers, steamfitters, at Hartford, Conn., and later entered the Walworth Manufacturing Company and then the Walker & Pratt Company, in Boston, Mass. He left the latter company to become chief engineer at the Boylston Hotel.

In 1880 Mr. Evans formed a partnership with Frederick Tudor, under the name of Tudor & Company, and engaged in the steamfitting business, and in 1881 entered into a partnership with Mr. Joslyn, as Q. N. Evans & Company of Boston and New York. Several years later Mr. Evans entered the Otis Elevator Company of New York as superintendent of construction, but in 1885 he again returned to the steamfitting business, forming the corporation known as the Q. N. Evans Construction Company. This concern was maintained under that name until 1895 when the present firm of Evans, Almirall & Company was formed.

During his early connection with the Q. N. Evans Construction Company, they designed and installed the heating and ventilating systems in the Leake and Watts Orphan Asylum of New York, the Criminal Court House of New York, and the English and Latin School, and also the heating and ventilating plant in the original capitol building in Albany, N. Y. He died on July 7, 1914.

Mr. Evans was a member of the Montauk Club of Brooklyn, N. Y.

JOHN DOWNING LOGAN

John D. Logan died at his home in Hillsdale, N. Y., on March 15, 1914. Mr. Logan was born on January 14, 1863,

in Brooklyn, N. Y., and was educated in the public schools of Brooklyn. For a time he attended the Polytechnic Institute of that city and was graduated from Columbia College in 1884. He served his apprenticeship with John Roach & Sons, shipbuilders, at Chester, Pa., and in 1885 entered the Logan Iron Works in Brooklyn, of which he was for many years secretary and superintendent.

Mr. Logan was regarded as one of the most shrewd and intelligent of engineers, and was frequently sought out to solve some very difficult problem. He made many improvements in steel working machines, which, however, he never patented. He was responsible for the simplification and improving of the shields used in the tunnels on both the North and East Rivers.

Mr. Logan was also secretary of the Logan Real Estate Company, and was a member of the Illuminating Engineers Society.

WILLIAM BLEECKER POTTER

William Bleecker Potter, founder and manager of the St. Louis Sampling & Testing Works and one of the best known mining engineers and metallurgists in the United States, died at his home in St. Louis on July 14, 1914.

Mr. Potter was born in Schenectady, N. Y., March 23, 1846, and received his A.B. degree at Columbia in 1866, his A.M. in 1869, and his E.M. in the School of Mines, Columbia, in 1869. After his graduation he studied for a time in Germany. He acted as assistant in geology at Columbia from 1869 to 1871, and was an assistant in geological survey in Ohio.

In 1871 he was appointed professor of mining and metallurgy in Washington University, the year in which this chair was founded, and remained at the head of the department, which had a phenomenal growth, until 1893. The department was abandoned after his resignation.

He founded the St. Louis Sampling & Testing Works in 1886 as a metallurgical and chemical laboratory for the benefit of the students of Washington University.

In 1889 he was placed on the board of the Missouri Geological Survey and served until 1893. He was an assistant in geological survey in Missouri from 1872 to 1874, engineer of the Pilot Knob Iron Company, 1874 to 1878, metallurgist for the Vulcan Iron and Steel Works, 1876 to 1878, and chief engineer of the Iron Mountain Mining Company from 1882 to 1893.

Mr. Potter was widely known both as a practising and consulting engineer. He was a past-president of the American Institute of Mining Engineers and of the St. Louis Engineers' Club, and a member of the Mining and Metallurgical Society of America, and a corresponding member of the New York Academy of Science, Wisconsin Academy of Science and National Geographic Society.

He received the honorary degree of Sc.D. from Columbia University in 1904 in recognition of his services in the field of mining and metallurgy.

SIDNEY LEROY SMITH

Sidney Leroy Smith, who was born in Boston, Mass., March 29, 1838, died in the same city on May 25, 1914. He was graduated from Dartmouth College with the B.S. degree, and his first position was as resident engineer in charge of the construction of a railroad between Sheboygan and Fond du Lac, Wis. In 1861 he entered the engineer corps of the United States Navy, continuing in the service after the close of the war. At the time of his resignation in 1884 he was acting as assistant engineer. From 1894 to 1897 Mr. Smith was superintendent of the Roxbury Carpet Company, Boston, Mass.

Mr. Smith was a member of the American Society of Naval Engineers and of the Loyal Legion.

ALFRED P. TRAUTWEIN

Alfred P. Trautwein, vice-president of the American Welding Company, Carbondale, Pa., died at his home in that city on August 5, 1914. He was born in New York City on October 10, 1857, and was graduated from Stevens Institute of Technology in 1876. In the same year he entered the employ of the Continental Iron Works, Brooklyn, as mechanical draftsman and engineer, engaged in the construction of coal and water gas works, fuel gas plants, ice making and refrigerating machinery and marine construction. In 1889 he removed to Carbondale and entered the Hendrick Manufacturing Company as superintendent and consulting engineer. Ten years later he organized the Carbondale Machine Company and was president for a number of years. He also organized the Carbondale Supply Company, the Carbondale Chemical Company, now known as the Carbondale Calcium Company, the American Welding Company, and the Carbondale Instrument Company. He was also one of the reorganizers of the Consolidated Telephone Company and until recently was one of its directors. At one time he acted as president of the American Acid and Alkali Company of Bradford, Pa., and was a former director of the Buffalo Cold Storage Company, Buffalo, N. Y. Mr. Trautwein was also one of the organizers and until a short time ago one of the directors of the Pioneer Dime Bank. During the past three years he had devoted the greater part of his time to the Barium Products Company of Scranton, Pa., of which he was president. He was a director in the Carbondale Machine Company and the American Welding Company at the time of his death.

Mr. Trautwein first pointed out the advantages of the anthracite coal region for the silk industry, and it was through his persistent efforts that the chain of Klots Mills was located in the region of Carbondale. This was followed in turn by the Empire Silk Company, and Mr. Trautwein was himself one of the organizers of the Carbondale Knitting Company. He did much throughout the valley to develop its industrial interests, and while he never took an active part in politics he was always ready and willing to lend financial and moral support to every movement instituted for the welfare of the community.

He served Stevens Institute in the capacity of alumni trustee from 1887 to 1890, and was a member of the Engineers Club of New York, the Manufacturers Club of Scranton, the Engineers Club of Scranton, and the Drug Trade Club of New York.

BRAKE PERFORMANCE ON MODERN STEAM RAILROAD PASSENGER TRAINS

ABSTRACT OF RESULTS OF THE PENNSYLVANIA RAILROAD BRAKE TESTS, 1913

By S. W. DUDLEY[1], PITTSBURGH, PA.
Non-Member

Realizing the significance of the knowledge and experience accumulated in recent years, the Pennsylvania Railroad, in conjunction with the Westinghouse Air Brake Company, instituted in the spring of 1913 the most scientific and comprehensive investigation of the different factors affecting the operation of brakes on steam railroad passenger trains that has been undertaken since the Galton-Westinghouse trials of 1878 and 1879. In addition to an examination of the characteristics of brake shoe friction throughout a wide range of laboratory and operating conditions, the test included also a study of the effect of various types of air brake mechanisms and foundation brake rigging and different degrees of emergency braking force. The tests indicated the degree to which existing apparatus was suited to existing conditions, the direction in which improvement was necessary and could be made, and the amount of improvement actually accomplished.

A TRAIN of 12 steel passenger cars and modern locomotive weighs nearly 1000 tons, is about 1000 ft. long and, at 60 m.p.h. speed has a kinetic energy of 224,000,000 ft-lb.

With the ordinary high-speed brake apparatus such a train would be stopped by an emergency application of the brakes in a distance of from 1600 to 1800 ft., according to the truck rigging and brake shoe design and installation.

In making ordinary brake applications for slow-downs or station stops, skill and judgment must be carefully exercised in order to avoid shocks and make short and accurate stops.

The Pennsylvania Railroad brake tests of 1913 showed that such a train at 60 m.p.h. speed can be stopped by an emergency application in 1000 ft. or within the length of the train. They also showed that trains can be controlled by service applications without shocks at any speeds and with greater accuracy and promptness and still require less expert knowledge and skill on the part of the manipulator.

The improvement in emergency stopping power has resulted from applying the air brakes more quickly and to a higher pressure, holding this higher pressure without diminution toward the end of the stop, using a more efficient design and better installation of foundation brake rigging and providing a better method of applying the brake shoe to the wheel and more brake shoe metal to absorb the heat developed during the process of stopping.

The greater efficiency, economy and flexibility in service has been attained by making the air brake apparatus more positive and responsive in its operation, both in application and release, enabling full advantage to be taken of all the possibilities of these improvements through the quick, simultaneous and flexible action obtainable only with electric control, the maintenance of a high and uniform brake rigging efficiency, and the improved truck, journal and brake shoe action, less wear of brake shoes and better distribution of forces and reactions accompanying the use of the clasp brake having two shoes per wheel, instead of concentrating the heavy braking forces required by modern equipment on only one side of the wheel.

The tests constitute a scientific study of the brake as a whole; comparing in detail the characteristics of the ordinary high-speed air brake apparatus with the improved electro-pneumatic brake, the effect of low and high emergency braking powers, the clasp with the single shoe type of brake rigging, the relative advantages of one and of two brake shoes per wheel and investigating the limitations of track and operating conditions commonly experienced.

The improved air brake apparatus operating pneumatically, shortens the time of obtaining maximum emergency brake cylinder pressure on the train as a whole from 8 seconds, with the PM equipment, to 3.5 seconds, and with electric control this is again shortened to 2.25 seconds. Moreover, 125 per cent, 150 per cent or 180 per cent emergency braking power is available as may be thought desirable or found permissible according to circumstances when the installation is made. The PM average is 100 per cent.

Using 150 per cent emergency braking power, the quicker and more powerful pneumatic emergency application shortened the stop at 60 m.p.h. from over 1600 ft. to about 1400 ft. and the simultaneous action of the electro-pneumatic brake still further shortened the stop to less than 1200 ft.

With the PM equipment the attempt to make an emergency application during the progress of or before releasing a partial or full service application will produce only the same stop as if merely a full service application had been made. Considering the ordinary full service stop from 60 m.p.h. (say 2000 or 2200 ft.) as 100 per cent; with the improved apparatus, operating pneumatically, an emergency application following a partial service application will shorten about 14 per cent and after a full service application about 10 per cent; with electro-pneumatic operation the gain is 23 and 15 per cent respectively.

Shocks during brake applications are due to slack action modified by speed. This was shown by pneumatic and electro-pneumatic stops from both high and low speeds. At high speeds, 60 to 80 m.p.h., the serial action of the pneumatic emergency application resulted in noticeable shocks which increased in severity at lower speeds and at 10 m.p.h. amounted, in effect, to a collision between the rear and forward end of the train, the train being stopped in 42 ft. The simultaneous application of just as great retarding forces by the electro-pneumatic brake entirely eliminated violent slack action at all speeds.

[1] Assistant Chief Engineer, Westinghouse Air Brake Co.

I. THE BRAKE PROBLEM

The object of the Pennsylvania Railroad Tests of 1913 was to make as thorough a study as might be found practicable of the variables encountered in braking equipment, and their effects, with particular reference to:

A A determination of the maximum percentage of emergency braking power which can be adopted, considering:

- *a* The type of brake shoe to be used
- *b* The type of brake rigging to be adopted
- *c* The type of air brake mechanism and control to be adopted
- *d* The degree to which occasional wheel sliding is to be permitted under favorable circumstances
- *e* The variation in the condition of the rail surface for which it is considered necessary to provide

B A comparison of the relative performance of the clasp brake rigging (two shoes per wheel) and the standard brake rigging (one shoe per wheel) with regard to:

- *a* Maintenance of predetermined and desired piston travel
- *b* Efficiency of transmission of forces
- *c* Effect upon wheel journals, bearings and truck
- *d* Mean coefficient of brake shoe friction for the standard plain cast iron shoe

C A comparison of the performance of the improved air brake mechanism (type UC) with that of the commonly used "high speed" (type PM) brake equipment with regard to:

- *a* Efficiency and effectiveness, as shown by the length of service and emergency stops
- *b* Safety and protective features
- *c* Flexibility and certainty of response to any manipulation of the engineer's brake valve
- *d* Uniformity of action of individual equipments associated in the same train and of any individual equipment at different times
- *e* Smoothness of riding during stopping, slack action between cars, and the resulting shocks
- *f* Capacity for future requirements

D The behavior of the brake shoes as the tests progressed and any variation in the results of similar tests which could not be accounted for by known changes independent of the brake shoe. One type of brake shoe was to be used throughout the range of the tests. Relating to objects *A, B,* and *C,* advantage was taken of this opportunity to establish as definitely as possible the characteristics of this type of brake shoe under the influence of various combinations of speed, pressure, time, weather and the conditions of the brake shoe.

E The coefficient of friction between the wheel and the rail under varying weather conditions.

In addition to the investigations outlined in general above, it developed during the tests that additional data were desired regarding the performance of brake shoes under certain specific conditions. In consequence a series of experiments was carried out at the laboratory of the American Brake Shoe and Foundry Company, at Mahwah, N. J.

FEATURES OF EQUIPMENT AND APPARATUS TESTED

Air Brake. Experience has shown that under the severe requirements of today the type PM equipment lacks many of the features necessary to obtain a desirable degree of stopping power in emergency applications and prompt and certain response at all times in ordinary service brake manipulation. One of the objects of the tests scheduled for this type of equipment was to determine its limitations and serve as a standard of reference to measure the betterment made possible by the improved features of the new air brake apparatus, the more efficient design of foundation brake rigging and more satisfactory brake shoe performance.

The special features of the improved air brake equipment (type UC) which received more or less attention during the tests may be summarized as follows:

A Adaptability of the electro-pneumatic brake equipment to meet any requirement, with a degree of efficiency as high as the existing physical conditions will permit.

B Possibility of installation to produce any desired cylinder pressure, either in service or in emergency.

C Gain by use of the electric control, in addition to the pneumatic, in the elimination of the time required for the transmission of the action of the brake from car to car and, in addition the elimination of shocks and uncomfortable surging which results from the non-simultaneous application of the brakes on all cars.

D Troubles due to brakes failing to release, as well as the undesired application of brakes due to unavoidable fluctuations of brake pipe pressure when running over the road.

E Adequate supply of air available at all times.

F Emergency braking power available at any time, even after a full service application of the brake.

G Adaptability of the equipment to all weights of cars and to any desired percentage of braking power, eliminating necessity of two brake equipments for heavy cars or two service brake cylinders, except for cars weighing more than the limit of the service capacity of one brake cylinder.

Brake Rigging. Duplicate tests were made with the clasp brake rigging, two shoes per wheel, for every test made with the standard brake rigging, one shoe per wheel, in order to bring out the advantages of the clasp brake in the following desirable features: (*A*)

Abstract of paper presented at the New York local meeting of The American Society of Mechanical Engineers, on February 10, 1914. Complete copies may be obtained, price, 60 cents to members and $1.20 to non-members.

constant piston travel for all cylinder pressures; (*B*) smoothness of action during stopping; (*C*) greater certainty of obtaining and maintaining the predetermined braking force contemplated in the design of the air brake equipment and foundation brake rigging; (*D*) less displacement of journals, bearings and trucks, tending toward greater mechanical efficiency and less cost of maintenance; (*E*) a coefficient of friction equal to or greater than that with the single shoe brake, with less wear of brake shoe metal and lower brake shoe temperatures.

TRAIN MAKE-UP AND EQUIPMENT

The test train was 1040 ft. long, consisting of a Pacific type locomotive and tender of the P. R. R. K2s class, weighing in working order about 200 tons, and 12 P-70 steel passenger cars averaging about 61 tons each. These cars have 4 wheel trucks with one 16 in. brake cylinder per car.

The ET air brake equipment was used without any modification on the locomotive, except that in some tests an auxiliary device was used which increased the braking power obtained during the early portion of the stop.

All tests were made under road service conditions, except where otherwise noted, the air brake regulating devices on the locomotive and cars being adjusted as follows: Pump governor, low-pressure head 130 lb. maximum pressure head 140 lb., feed valve, 110 lb., and ET distributing valve safety valve, 68 lb.

The cars were equipped with the present standard air brake apparatus (PM) and with the improved type of air brake equipment (UC), these installations being so arranged that a complete change from the standard equipment (PM) to the new equipment (UC) having PM features only or the complete pneumatic features of the new equipment or to the new equipment with complete electrical control could be quickly made.

The standard brake rigging as originally applied to the cars of the test train is shown in Fig. 3. With the No. 3 design of clasp brake rigging shown in Fig. 4 the best stops were made, fulfilling what it was anticipated should be obtained from the application of two brake shoes per wheel. The No. 3 clasp brake rigging was used only in single car break-away stops, there being but one car equipped with this type. Diagrams of the lever arrangement of the various types of brake rigging tested are shown in Fig. 5.

The standard plain cast-iron brake shoe was used in most of the tests. In several tests flanged, slotted and half area shoes were employed. Special care was taken to insure uniformity in quality and condition of all shoes at the beginning and during the progress of the tests.

The high-speed reducing valves of the PM equipment were adjusted to open at 62 lb. brake cylinder pressure. The standing piston travel was adjusted before each run to 6½ in. with a full service brake application.

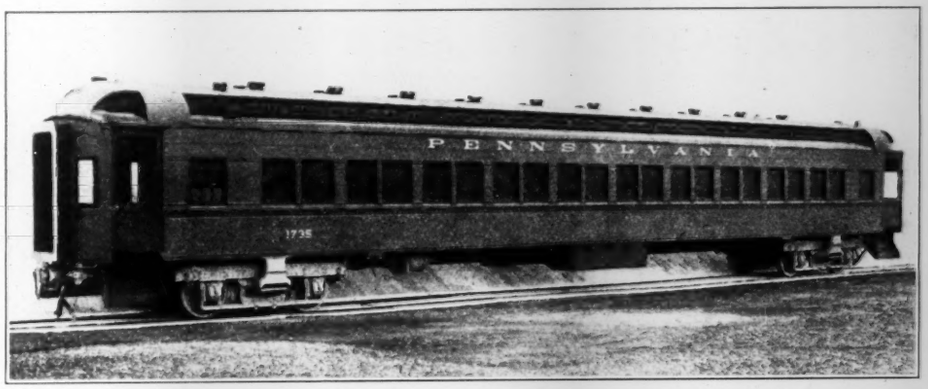


Fig. 1 Class P-70 Steel Car—Twelve of this type used in the Test Train

TEST APPARATUS AND OBSERVATIONS TAKEN

Locomotive. The apparatus on the locomotive consisted of the usual gages which indicated main reservoir, brake pipe, and brake cylinder pressures, and in addition a brake cylinder indicator was used on the tender brake cylinder and served to measure the pressure in all of the brake cylinders of the locomotive and tender, viz., one engine truck, two driver brake, one trailer truck and one tender brake cylinder. A voltmeter, calibrated in m.p.h. was connected to a generator, belt-driven from the right front engine truck wheel, and served as a guide to the engineman in obtaining the desired speed.

A device for recording automatically the distance traveled by the train beyond the point of brake application was driven from the left engine truck wheel and was used in connection with the wheel sliding indicators on the cars.

Devices similar to those used in former brake tests were employed to operate the track circuit breakers and to automatically apply the brakes at the zero circuit breaker.

On the locomotive, observations were taken of the

time of stop and the main reservoir and brake pipe pressure, the tender piston travel and the amount of coal and water on the tender.

Cars. Each car was furnished with a brake cylinder indicator, and a wheel sliding indicator, with the necessary wiring and connections.

A chronograph, recording the distance of stop, time of stop, deceleration of train, the brake cylinder pressure and the brake pipe pressure, was located on car six. In connection with this chronograph a record was made of the action of the brake shoes with respect to sparking.

Indicators for measuring the slack action between the cars were used at different points in the train.

Specially designed apparatus was used to measure the pressure delivered to the brake shoes during some of the tests, the object of which was to determine the efficiency of the brake rigging.

After each test measurements were taken of the total length of the stop, and also the running piston travel on each car.

Rail Friction Machine. Of the devices used on the track, the only one which requires special mention is the machine for measuring the force required to move or keep moving a block of tire steel resting upon the rail. The pressure of this block on the rail could be varied by means of weights of 20, 40, 60, 80 and 100 lb. Readings were taken with each of these weights and the coefficient of rail friction recorded was derived from the average of the five readings.

When making a test run the engineman endeavored to reach a speed slightly above that desired, just before entering the measured track. The throttle was closed just before reaching the circuit breakers preceding the zero point, no change being made in the position of the reverse lever. The train then drifted over the

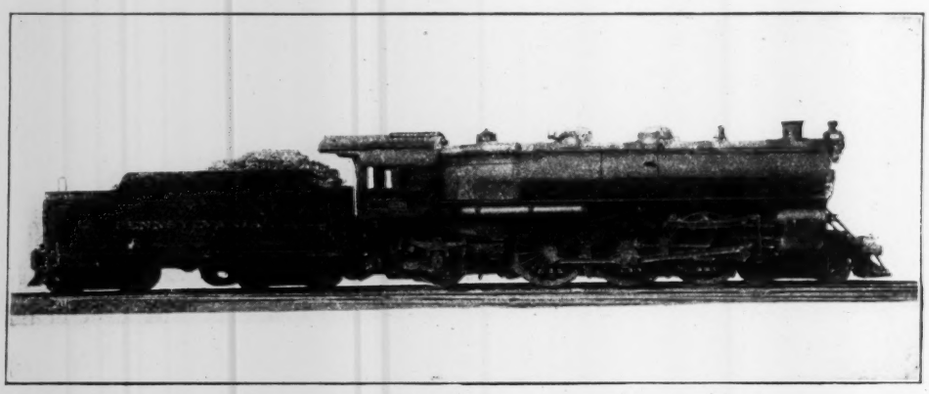


Fig. 2 Class K2sa Locomotive—used in the Test Train

Telephones were located in the first, third, sixth, ninth and twelfth cars and greatly facilitated the issuing of instructions.

Track. The tests were made on the south bound track of the Atlantic City Division of the W. J. & S. R.R. The portion of the track over which the braking was done was level, and part of a tangent about 25 miles long terminating at Absecon Station. A slight descending (0.3 per cent) grade approaching the measured test track was in favor of the train attaining speed.

The track for a distance of 5000 ft. south of the zero point was wired for circuit breakers, which were placed at intervals of 25 ft. up to 1200 ft. from the zero point, and at intervals of 50 ft. from there on to the 5000 ft. point. Preceding the zero point, eight circuit breakers were located, 66 ft. apart from which the initial speed of train (speed at the trip) was determined.

A cabin, located near the zero circuit breaker, contained the clock and chronograph from which in connection with the track circuit breakers, the speed of the train before and during the stop was obtained.

circuit breakers preceding the zero point at which point the brake was automatically applied by the trip mechanism. At the instant the brake pipe exhaust started at the trip, the brake valve handle was moved to emergency position for all emergency tests and to lap position for all service application stops. When the engine and cars were to be stopped separately (breakaway tests), the same procedure as above was followed, except that the coupling pin between the engine and tender was pulled out as soon as possible after steam was shut off. This permitted the engine to pull away from the train as soon as the brake application was made, providing the retardation of the cars was higher than that of the locomotive.

However, the engine did not always separate from the train when making stops with low braking powers on the cars. On this account it was decided to use steam on the locomotive in such tests as soon as the coupling pin was pulled out, so as to get the locomotive away from the cars and permit the cars to stop without any possible interference on the part of the locomotive, the stop of the locomotive in such cases being

disregarded. For such stops the flexible wiper and the tripping mechanism were on the first car instead of the locomotive.

In all 691 tests were made, at Absecon, in 91 days, covering a period of time from February 10 to May 22, 1913. These were divided with respect to the type of brake rigging equipment, whether standard single shoe or clasp Nos. 1, 2 or 3, and to form of brake shoe used, whether plain or flanged. The average day's work consisted in making from 10 to 12 runs, a maximum of 22 tests being made in one day.

II. AIR BRAKE EQUIPMENT

The quick action automatic brake (PM equipment), which is the present equipment on P.R.R. P-70 cars, is illustrated in Fig. 6. It comprises a 16-in. brake cylinder with automatic brake slack adjuster set for 8-in. running piston travel, a 16-in. by 42-in. auxiliary reservoir and a quick action triple valve, which controls the flow of compressed air:

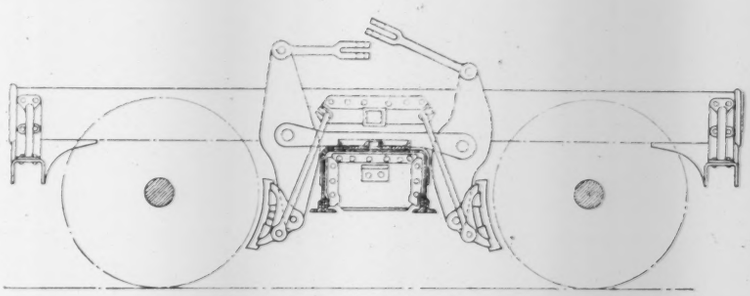


Fig. 3 The Standard Brake Rigging as Modified for Test

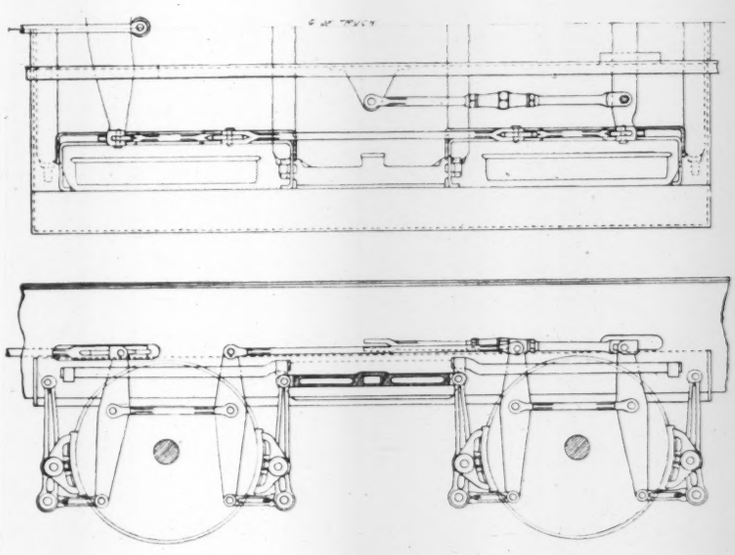


Fig. 4 The No. 3 Clasp Brake Rigging

a From the brake pipe to the auxiliary reservoir for charging the system.

b From the auxiliary reservoir to the brake cylinder for applying the brakes.

c From the brake cylinder to the atmosphere when releasing.

d From the brake pipe to the brake cylinder, as well as from the auxiliary reservoir to the brake cylinder, when a quick action application of the brakes is desired.

A high speed reducing valve designed to perform the functions of a safety valve during service brake applications, limits the brake cylinder pressure to a maximum, predetermined as satisfactory for service operations (62 lb.). In emergency applications the high speed reducing valve retains the maximum cylinder pressure practically constant for a period of time and then by an accelerating blow down, reduces the brake cylinder pressure to 60 lb. This reduction is designed to compensate for the increased effectiveness of the brake shoes as the speed diminishes. The compressed air required to charge the auxiliary reservoir is all supplied from the brake pipe through a feed groove around the triple valve piston when in release position only.

The certainty of releasing all brakes in the train depends on the possibility of establishing the differential pressure required to move the triple valve parts to release position. No difficulty is experienced in this direction so far as the cars at the head end of the train are concerned, but the increase in brake pipe pressure is necessarily slower at the rear than at the head end. Large auxiliary reservoir volumes, requiring a large amount of air for recharging (all of which must be drawn from the brake pipe), long trains, leaky brake pipe, poor condition of triple valve piston packing rings or slide valves, low main reservoir pressure, or light brake pipe reductions, all tend to bring about the slow rise of brake pipe pressure at the rear end of the train, which results in failure to release brakes, slow release, stuck brakes and dragging brake shoes.

The brake cylinder pressure in emergency is under the control of the high-speed reducing valve at all times. At first the reducing valve blows down the brake cylinder pressure at a very slow rate, but this rate gradually increases, being timed to become relatively rapid as the train nears its stopping point and the valve then closes at 60 lb. brake cylinder pressure.

It is impossible to obtain a quick action application with the PM equipment after a service application of any consequence has been made.

FEATURES OF THE UC EQUIPMENT

The valve mechanism which is the distinguishing feature of this equipment is of the "built-up" type which makes it possible to install and operate this

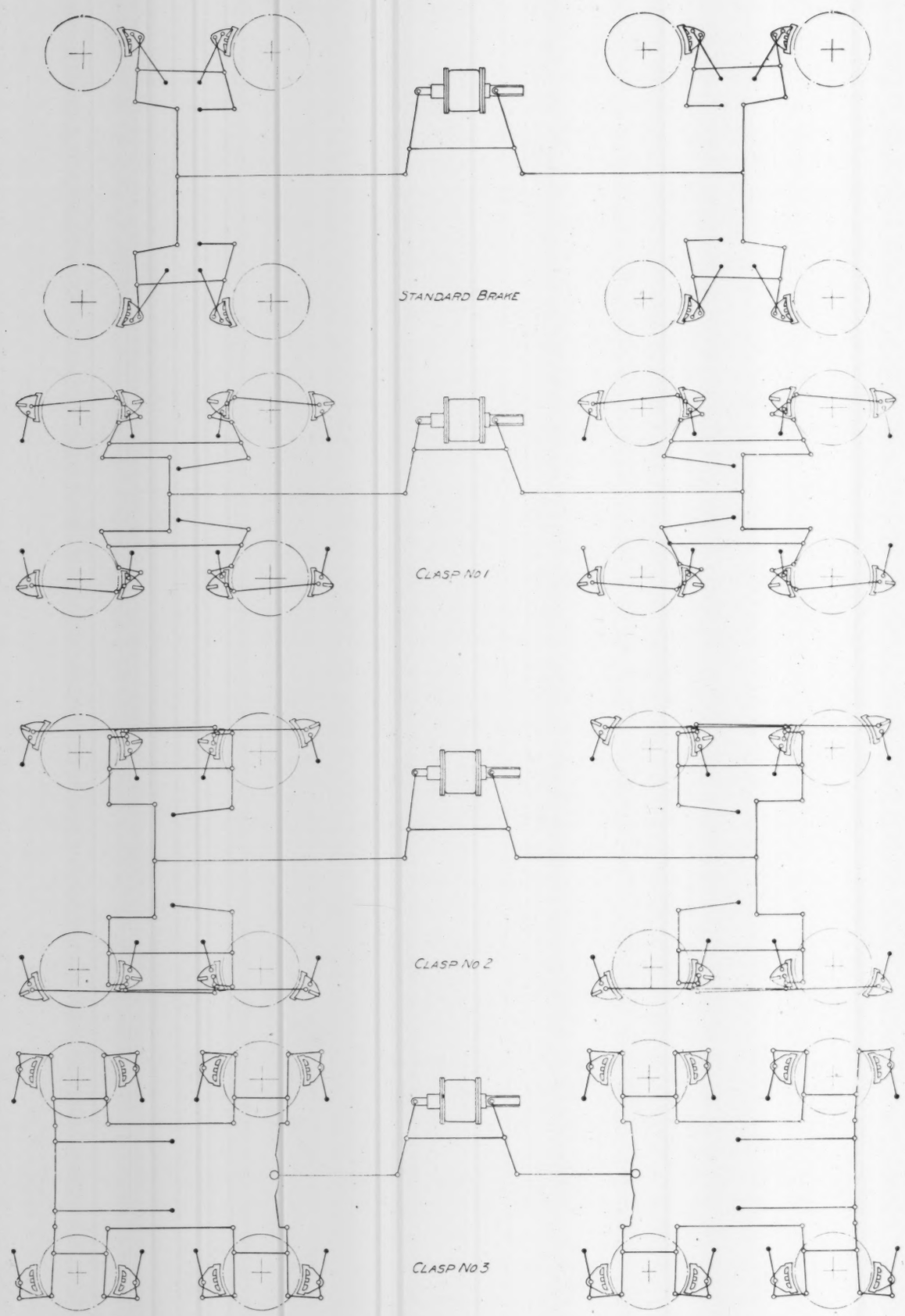


FIG. 5 OUTLINE DIAGRAM OF LEVER ARRANGEMENTS OF THE FOUR BRAKE RIGGINGS USED

equipment if desired in stages, by adding to the simplest arrangement of apparatus, including only those features required to give an operation equivalent to that of the PM brake, up to the complete form of the device.

The UC equipment, Figs. 7 and 8, in its complete form comprises a valve mechanism called the universal valve with its permanent pipe bracket and three reservoirs, the auxiliary, the service and emergency reservoirs.

The universal valve (Figs. 9 to 12), consists of an equalizing portion, which primarily controls the charging and recharging of the reservoirs of the equipment, the service application of the brakes and the releasing of the brakes.

A quick action portion with high pressure cap, which controls the transmission of serial quick action and obtaining of high emergency pressure in the brake cylinders when an emergency application of the brakes is made.

An electric portion, which comprises the magnets, switch, etc., controlling the electric service application, electric release and electric emergency applications of the brakes.

A pipe bracket, to which all pipe connections are permanently made and to which the various portions of the valve device are bolted. This bracket contains two small chambers, the quick action chamber and quick action closing chamber.

The *quick action closing chamber* provides means whereby the quick action outlet from the brake pipe to the atmosphere is open when an emergency application is made and is closed when a predetermined time thereafter has elapsed.

The *quick action chamber* in connection with the quick action closing chamber controls the operation of the quick action parts of the valve in accordance with the rate of brake pipe reduction.

In addition to the above the equipment on each car comprises:

An auxiliary reservoir which is the same size for all sizes of brake cylinders, the pressure in which controls the movement of the equalizing piston and slide valve of the universal valve and supplies air to the brake cylinder. The UC equipment has one size smaller auxiliary reservoirs than the PM equipment, being designed to give a brake cylinder pressure of 50 lb. per sq. in. when a 20 lb. brake pipe reduction is made; and furthermore, the braking power basis is 90 per cent instead of 80 per cent, as with the PM equipment.

A service reservoir which varies in size with the size of the brake cylinder. This, together with the auxiliary reservoir, supplies air for operating the brake cylinder in service and emergency brake applications.

An *emergency reservoir* which varies in size according to the size of brake cylinder used and the amount of emergency brake cylinder pressure which the installation is designed to afford. This reservoir supplies air required to graduate the release of the brakes and to obtain a quick recharging of the service and auxiliary reservoirs after a service application of the brakes. It also provides the additional supply of air required to obtain the increased brake cylinder pressure desired for emergency applications.

The valve mechanism is designed to require a drop in brake pipe pressure of approximately 4 lb. before it is possible to obtain an application of the brakes. The equalizing piston moves on a differential much lower than this, however, so as to close the feed groove and thus prevent back leakage from the auxiliary reservoir. Thus a service application of the brakes is positively insured when the required 4 lb. brake pipe reduction is reached. From this point the rise in brake cylinder pressure corresponds to the reduction in brake pipe pressure in the proper relation to produce a full service brake application (90 per cent braking power) for a brake pipe reduction of 24 lb.

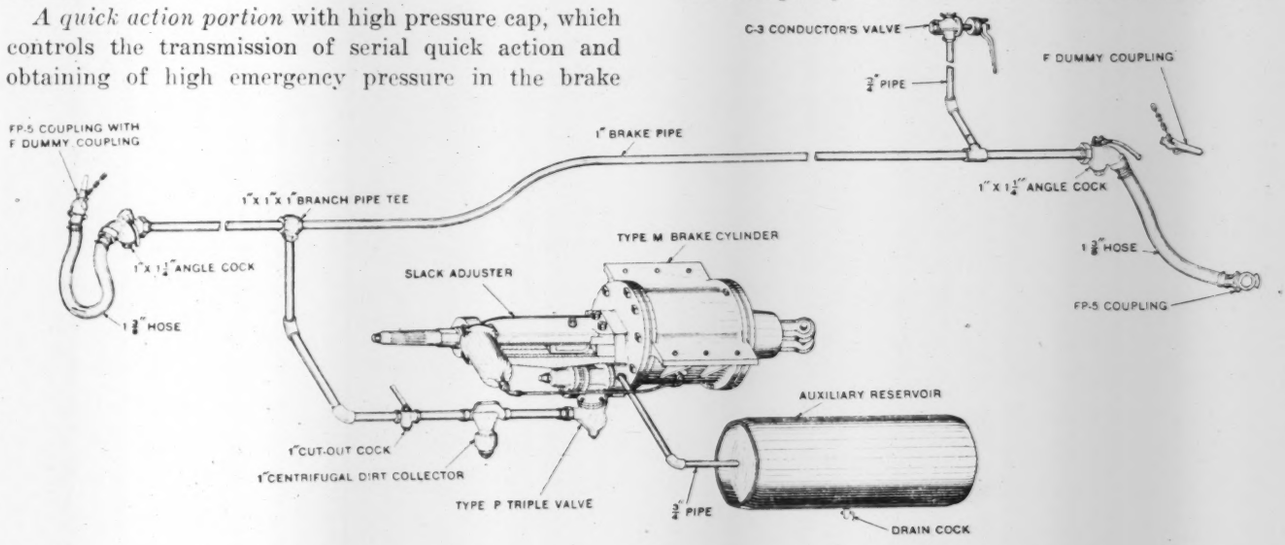


FIG. 6 ELEMENTS OF THE QUICK ACTION AUTOMATIC BRAKE (STANDARD PM EQUIPMENT)

The maximum brake cylinder pressure obtainable in a service application is limited by the setting of a quick blow-down and positive acting safety valve which is connected to the brake cylinder through the emergency portion of the universal valve at all times except when an emergency application of the brakes is made. When making an emergency application, the safety valve is automatically cut off from communication with the rest of the equipment. This safety valve is adjusted to limit the maximum obtainable service brake cylinder pressure to 60 lb. per sq. in.

EMERGENCY BRAKE APPLICATION AUTOMATIC ON DEPLETION OF BRAKE PIPE PRESSURE BELOW A PREDETERMINED POINT

Whenever, from any cause, the brake pipe pressure is reduced to a predetermined value (30 lb.), the protection valve included in the emergency portion of the universal valve will operate and cause the parts of the emergency portion to move to their quick action positions and so start a quick action application of the brakes—the operation of the equipment then being as already explained.

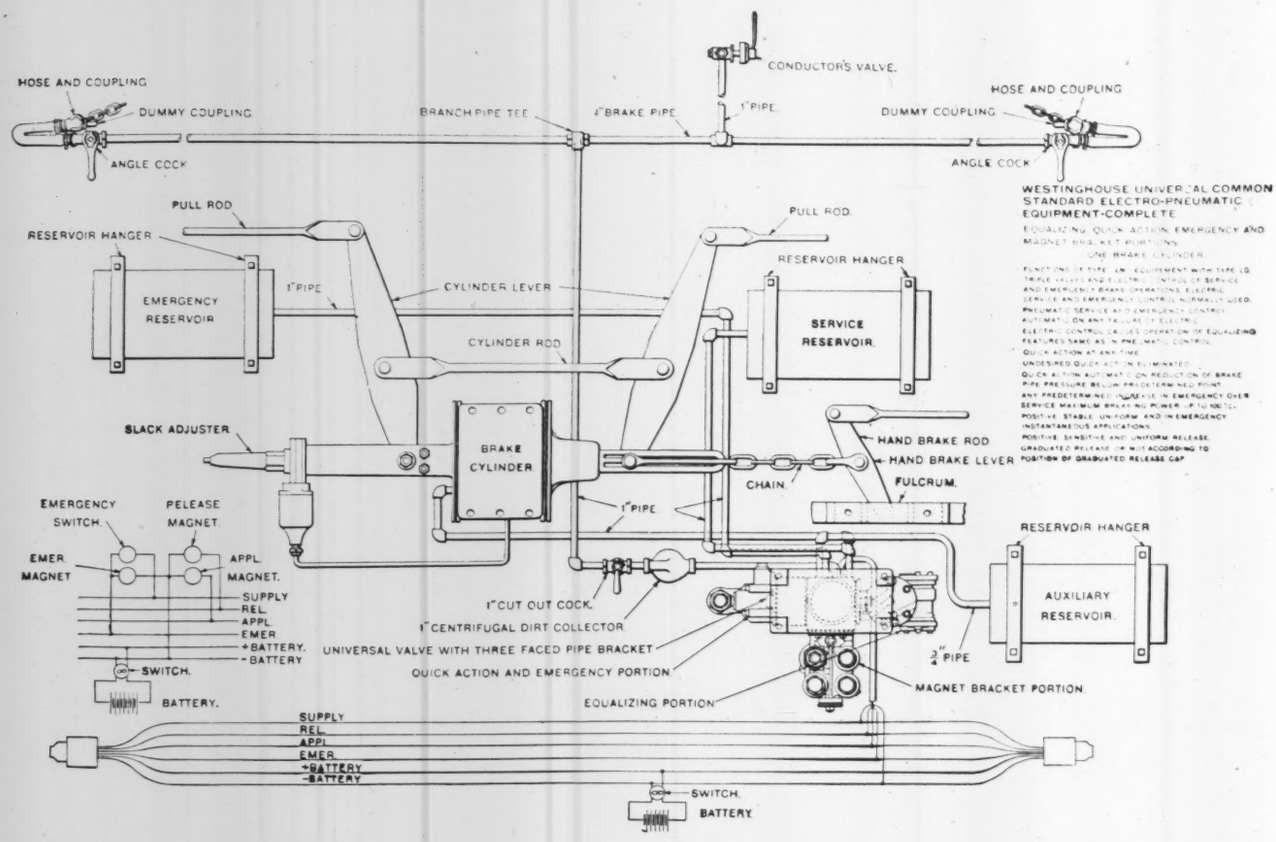


FIG. 7 DIAGRAM OF ELEMENTS OF THE COMPLETE ELECTRO-PNEUMATIC BRAKE AND CONNECTIONS (UC EQUIPMENT) FOR ONE CAR

EMERGENCY BRAKE APPLICATION AFTER SERVICE BRAKE APPLICATION

Whenever a predetermined emergency rate of brake pipe reduction is established the quick action and high pressure parts of the valve will operate as above described to start serial quick action and increase the brake cylinder pressure up to its full emergency value even though a partial or full service brake application had been completed or was in progress. That is to say, the obtaining of an emergency application of the brakes depends only on the functioning of the quick action parts and is entirely independent of the service operation of the valve.

Within certain limits the percentage of emergency braking power and the brake pipe pressure to be used may be chosen as the conditions of operation and installation may dictate without requiring a change in any essential part of the apparatus and without affecting the fundamental and proper relations between the different reservoirs, cylinders and operating parts of the equipment. For example, one or two brake cylinders per car may be used as the weight of the car and the percentage of braking power desired may require, the only change necessary being the use of a special cap on the high pressure portion of the valve designed to handle two brake cylinders instead of one. The

amount of emergency braking power can be fixed to suit special limits or requirements by proper choice of reservoir volumes and the arrangement of their connections. The equipment is designed to give normally an emergency braking power of 150 per cent when using 110 lb. brake pipe pressure; this insures a satisfactory stop on the one hand without the likelihood of injurious wheel sliding on the other, with an average condition of foundation brake rigging, track, etc. For the transition period, or where conditions of installation do not permit, or where the service requirements do not necessitate a braking power as high as this, a lower emergency braking power is available by the arrangement of reservoirs mentioned.

FEATURES OF ELECTRIC OPERATION

When operating electrically, the service application of the brakes is actuated by a reduction in brake pipe pressure as when operating pneumatically. The equalizing portion of the universal valve causes the brakes to apply in response to a brake pipe reduction as when operating pneumatically. But this brake pipe reduction is made locally on each car (instead of all at one place, namely, the engineer's brake valve). This local reduction of brake pipe pressure is accomplished by means of the service magnet valves which open simultaneously on each car and vent brake pipe air to the atmosphere at the proper rate to produce a service brake application when the service magnets are energized by the engineer's brake valve handle being placed in service position. The fact that the pneumatic and electric service position of the brake valve handle are the same insures the elimination of any delay in starting a pneumatic application of the brakes in case the electric control is, for any reason, inoperative.

The movement of the brake valve handle back to lap position de-energizes the service magnets, which permits their valves to close and thus stop the brake pipe reduction. The valve parts then assume their lap positions as when operating pneumatically.

Electric Release. Whether the graduated release cap is in direct or graduated release position, the release of the brakes can always be graduated electrically by alternately energizing and de-energizing the release magnets which control the flow of air from the brake cylinder exhaust ports to the atmosphere. These release magnets are energized and prevent the release of the brakes when the brake valve handle is in either release or holding position. At this time the brake pipe and reservoirs on the car are being recharged and the universal valve parts are in their release and charging positions. The outlet from the brake cylinder to the atmosphere is closed and the brakes cannot release so long as the release magnets are thus energized. The release magnets are de-energized and the exhaust of air from the brake cylinders permitted when the brake valve handle is in running position.

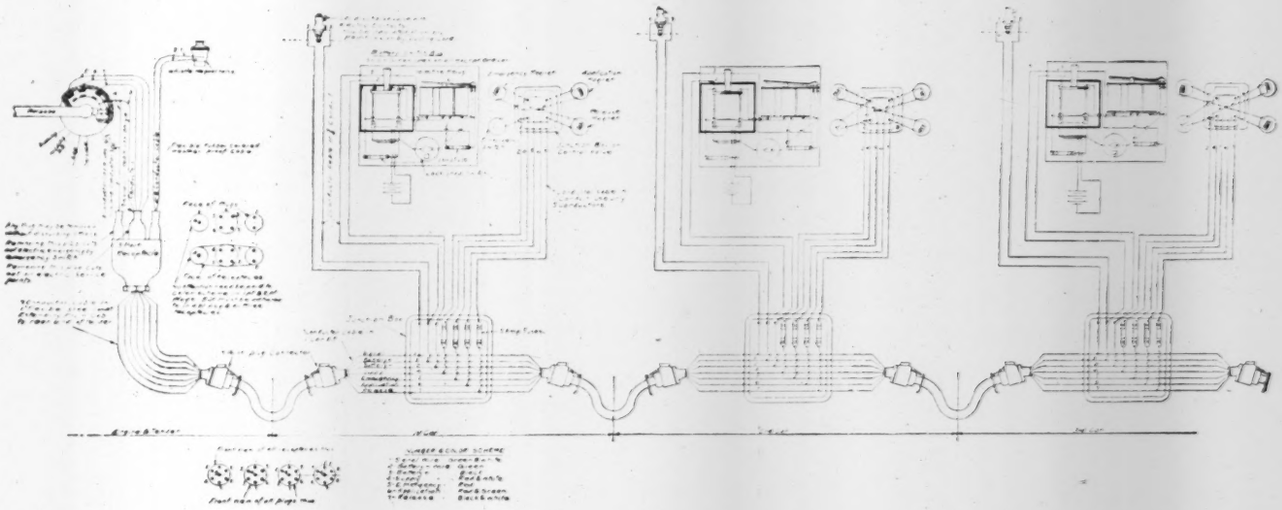


Fig. 8 Diagram of Electric Circuits of the Electro-Pneumatic Brake on Locomotive and Cars (UC Equipment)

Electric Emergency. In an electro-pneumatic emergency application, the emergency magnets on all cars are simultaneously and instantaneously energized. These magnets open their respective emergency magnet valves which in turn cause the quick action parts of each universal valve to operate and produce an emergency application of the brakes. In case a hose bursts or a conductor's valve is opened, the first universal valve to be affected by the resulting drop in brake pipe pressure will operate pneumatically.

DEVICE FOR OBTAINING HIGHER BRAKE CYLINDER PRESSURE ON LOCOMOTIVE AND TENDER

As is well known, the standard braking power of the ET equipment on the locomotive and tender (considering the ordinary working loads carried) is relatively

a little less or about the same in stopping effectiveness as that of the PM equipment on the P-70 cars. With the new and more effective car brake equipments, however, there was a marked difference between the stopping force on the locomotive and cars. The effect of this was to produce a noticeable running out of slack in ordinary train stops and in breakaway stops to cause the locomotive to run several hundred feet farther than the cars. To avoid this a bypass valve was devised and applied in experimental form to the locomotive brake equipment, so arranged that the service operations of the ET equipment were not affected in any way, but when an emergency application of the brakes was made the bypass valve operated so as to short circuit compressed air directly from the main reservoirs to all the brake cylinders on the locomotive and tender. This resulted in a much quicker rate of rise of emergency brake cylinder pressure and a much higher maximum pressure being obtained than is the case with the standard ET brake. To protect against the drivers sliding, the by-pass valve was arranged to hold the high initial brake cylinder pressure for a specified period (about ten seconds) and then, by a gradually accelerating blowdown, reduce this pressure so that as the speed of the train diminished the brake cylinder pressure would finally reach the normal emergency pressure standard with this equipment, namely, about 75 lb.

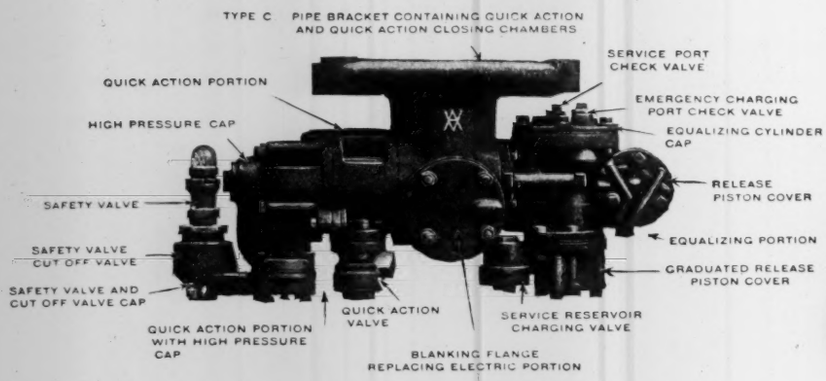


Fig. 9 Universal Valve, UC Equipment, Face View, without Electric Magnet Portion

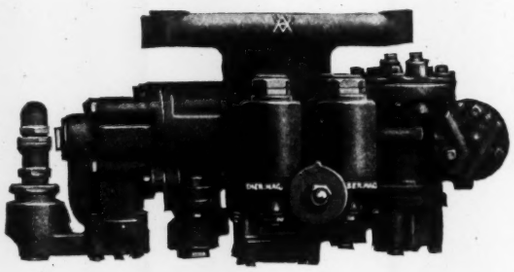


Fig. 10 Universal Valve with Electric Magnet Portion

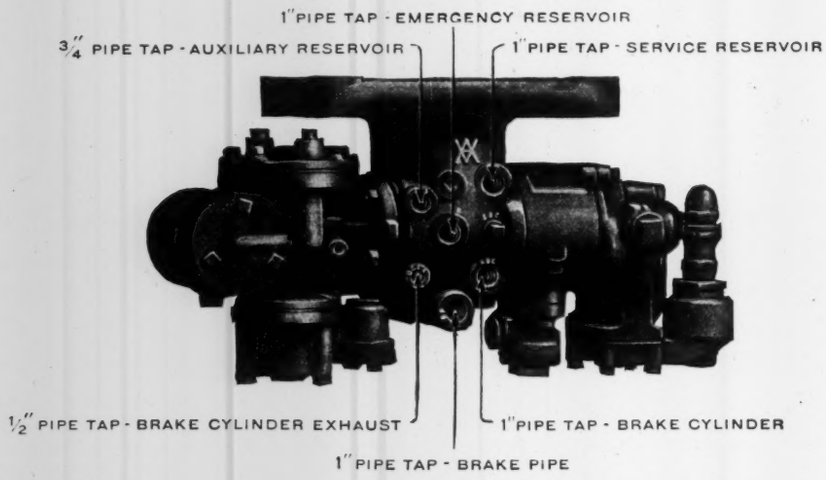


Fig. 11 Reverse Side of Universal Valve, UC Equipment, showing Pipe Connections

FULL SERVICE BRAKE APPLICATION

Standard PM Brake Equipment. The action of the PM equipment during a service application of the brakes, is illustrated by the curves (Fig. 13). The cars at the head end of the train begin to apply and reach their maximum pressure before those at the rear of the train, which is true of any form of pneumatically controlled brake. The time of commencing to apply on different cars varies through a range of about four seconds, which is an indication of the relatively slow serial response of the brake mechanism to a gradual fall in brake pipe pressure controlled by pneumatic means alone. From these cards and similar cards for the UC pneumatic equipment (Fig. 14), it is easily seen that there is a considerable time element involved in starting the service application of all the brakes in

the train when operating pneumatically. It follows from this that the rate of " build-up " of brake cylinder pressure in a service application must be relatively slow in order to avoid shocks which result from the brakes applying with a slow serial action combined with too rapid " build-up " of pressure on the individual cars.

The total time required to reach maximum full service brake cylinder pressure is nearly 12 seconds, which shows clearly the effects of the long train (large brake pipe volume) in extending the time required to make a pneumatic full service brake application beyond a minimum which is fixed by the design of the equalizing discharge feature of the brake valve; this requires that about 6 seconds at least be occupied in making a full service brake pipe reduction.

The rate of rise of brake cylinder pressure is more rapid than it would otherwise be, however, because of the use of the larger size auxiliary reservoirs with the PM equipments. For a given brake pipe reduction this results in a higher brake cylinder pressure than is obtained with a smaller size reservoir as used with the UC pneumatic equipment for the purpose of insuring flexibility of service operation of the brakes.

The maximum full service brake cylinder pressure is a trifle over 60 lb., which is equivalent to a nominal braking power of 80 per cent. The variations in the setting and the individual action of the different high-speed reducing valves is the cause of the varying degrees of maximum braking power obtained on the different cars.

UC Electro-Pneumatic Equipment. The advantages of the electro-pneumatic control of the service brake are apparent from a comparison of Fig. 15 with Fig. 14, which relates to the UC pneumatic equipment. With the electro-pneumatic brake (Fig. 15), the application started almost simultaneously on all cars and built up to maximum brake cylinder pressure at a uniform rate. Furthermore, the rate of build-up of brake cylinder pressure is not dependent upon the length of train as it is in the case of any pneumatically controlled service application. The maximum service brake cylinder pressure is obtained in about 8 seconds instead of 16 seconds, required by the same brake equipment operating pneumatically.

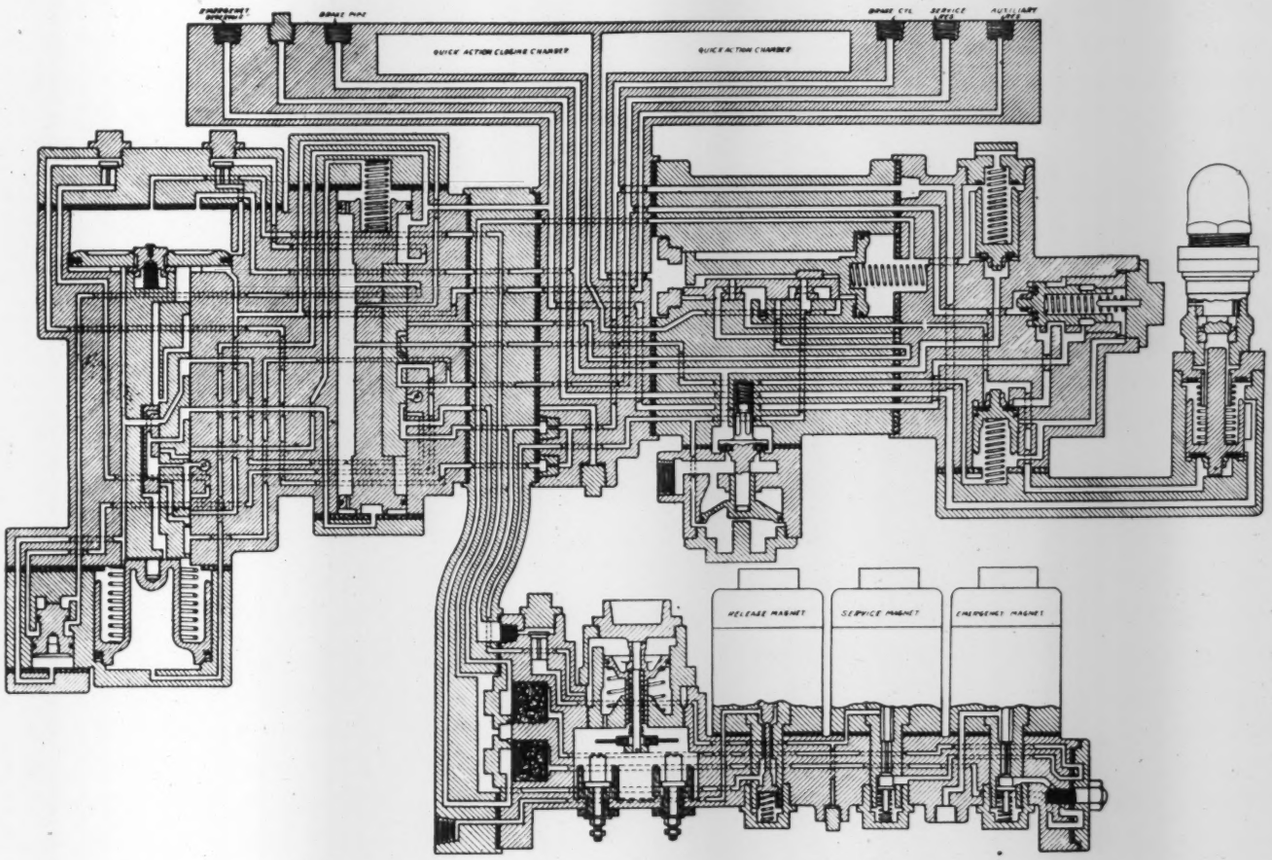


FIG. 12 DIAGRAMMATIC VIEW OF THE UNIVERSAL VALVE, UC EQUIPMENT, SHOWING SEQUENCE OF PARTS AND PASSAGEWAYS

PARTIAL SERVICE FOLLOWED BY EMERGENCY APPLICATION

PM Brake Equipment. Fig. 16 shows the results obtained with the PM equipment when a partial service brake application is made followed immediately by the movement of the brake valve handle from service to emergency position.

It is barely possible to distinguish signs of the emergency application from the shape of the curves when compared with a continuous full service application with this equipment without any emergency (Fig. 13). Slightly higher cylinder pressure was obtained on most of the cars sufficient to operate the high-speed reducing valves, but the rate of obtaining brake cylinder pressure is the same as if no emergency application had been made.

It should be noted that the serial action of the valves remains the same. There was no serial quick action effect produced by the emergency application following partial service application. The length of the stop, as would be expected, is but little different from that which was obtained with a full service application of the brakes, without any emergency application.

UC Pneumatic Equipment. In the case of the UC pneumatic equipment an emergency application produces serial quick action and full emergency brake cylinder pressure, whether preceded by a service application or not, Fig. 17. Consequently, when the emergency application was made all the brakes applied simultaneously, the brake cylinder pressure rose at the usual emergency rate and the usual emergency maximum cylinder pressure was obtained. The result of this is to shorten the stop by about 300 ft. compared with that obtained with a full service application.

UC Electro-Pneumatic Equipment. The action of the electro-pneumatic equipment (Fig. 18) is similar to that just described (Fig. 17), except that the time element due to the serial pneumatic application, both service and emergency, is eliminated, and the quicker rate of rise of brake cylinder pressure during the service application, which is due to the local venting of air from the brake pipe on each car, is produced by the electro-pneumatic service application feature. Both the service and the emergency applications occur on all cars simultaneously and the brake cylinder pressure rises as promptly on each car of a twelve car train as it would on a single car.

A direct result of the quicker rate of brake pipe reduction is that the partial service reduction determined upon is completed sooner and therefore the emergency application is made earlier in the stop than with the pneumatic equipment.

The result of these several advantages is to produce a much shorter stop (about 500 ft., Fig. 25) than with a full service electro-pneumatic application. This shows clearly the increased safety factor of the improved brake equipment over that now in service for conditions requiring the greatest possible stopping power after a service application of the brakes has been started.

EMERGENCY APPLICATION

PM Equipment. Fig. 19 shows characteristic brake cylinder indicator cards for PM equipment emergency applications. The rate of rise of brake cylinder pressure is slightly faster and the maximum pressure obtained slightly higher than would ordinarily be the case on account of the larger size of auxiliary reservoirs used.

The characteristic blow-down action of the high-speed reducing valve is clearly shown by the shape of the curves. The cylinder pressure is reduced from an average of about 78 lb. at the beginning to nearly 60 lb. at the end of the stop.

UC Pneumatic Equipment. Fig. 20 shows characteristic brake cylinder pressure cards obtained with this equipment, emergency application. The brake cylinder pressure rises almost instantly to its maximum value and is held without blow-down throughout the stop, thus utilizing the air pressure available on each car to its fullest extent and effect. The results to be expected from this quick rise of brake cylinder pressure are offset to a certain extent, however, by the relatively slow rate of transmission of serial quick action which resulted in the stop being somewhat longer and not as smooth as would have been the case otherwise.

The brake cylinder indicator cards (Fig. 20), show that the time of transmission of serial quick action was slightly longer than with the PM equipment. This was due to operation of the valve mechanism, and it was found possible to quicken the pneumatic serial quick action feature without any material change in the design of the parts.

UC Electro-Pneumatic Equipment. With the electro-pneumatic equipment a simultaneous and almost instantaneous application of the brakes in the train is obtained. The valve mechanism on each of the cars causes the brake cylinder pressure to rise to its maximum as quickly as the physical limitations of the air brake and foundation brake gear installation as a whole will permit and the maximum cylinder pressure thus obtained is maintained without blow-down (Fig. 22).

It should be noted that the only difference between the UC pneumatic and electro-pneumatic emergency applications is in the elimination of the time element in starting the application of the brakes on the various cars in the train. That this is an important gain, is shown by the fact that the emergency stops with the electro-pneumatic brake were from 200 to 275 ft. shorter than with the pneumatic equipment. The electro-pneumatic emergency stops are from 350 to 550 ft. shorter than those obtained with an emergency application of the PM equipment and also are devoid of shocks.

GRADUATED RELEASE STATION STOP AT 45 MILES PER HOUR

UC Pneumatic Equipment. This test was made to illustrate the proper method of making a graduated release stop. The initial application was made with one continuous full service brake pipe reduction, was then held a few seconds after which the release was graduated by moving the brake valve handle from lap to

running position and then back to lap position, four distinct graduations being made. This resulted in the braking power being reduced substantially in accordance with the decrease in the speed of the train.

Except for the first three cars in the train, which felt the effects of a graduation of the release most promptly and consequently tended to release sooner than the cars toward the rear, the amount of brake cylinder pressure remaining when the train stopped was uniform throughout the train. This stop was very smooth from the beginning of the application until the train came to a standstill and the low cylinder pressure remaining at the end entirely eliminated the unpleasant surging usually experienced when the train comes to a stop with high pressure in the brake cylinders.

III. BRAKE RIGGING

The only trustworthy indication we have of the relative performance of different brake riggings is in the length of the stop produced. But the stop is a resultant of both brake shoe and brake rigging performance, other conditions remaining the same. During these tests no satisfactory separation of the brake rigging and brake shoe performance during the process of stopping was effected. Consequently, when the stops produced by clasp brake rigging are being compared with those made by a rigging having but one shoe per wheel it is important to keep in mind that the performance in each case is a resultant of both brake rigging and brake shoe characteristics.

The various designs of rigging tested were the standard brake single-shoe type and three types of clasp brake known as Nos. 1, 2 and 3, respectively. The single-shoe brake used in these tests, shown in Fig. 3, had the strength of various rigging members increased to allow for the use of 180 per cent emergency braking power, the truck dead lever anchored to the car body center sill and the brake shoes hung about 4 in. below the horizontal center line of the wheel. The effect of the position of the brake shoes was to compress the truck springs during brake applications, causing horizontal movement of the brake shoes and a consequent increase in piston travel, which tended to reduce the effectiveness of the brake.

In the improved (No. 3) type of clasp brake, the members were so located that when the brake was applied, all the rods pulled perpendicularly to their respective levers and the pull rods rested on rollers, reducing the friction to a minimum. The shoes were hung as high as conditions would permit, being 2½ in. below the center line of the axle, the brake heads were pin connected to the hanger levers, enabling the shoe to adjust itself readily to the wheel. All possible reduction was made in the sources of loss in the transmission of forces from the brake cylinder to the brake shoe.

TESTS MADE AND RESULTS

The standard (single shoe) brake rigging was tested under various conditions of speed, air brake equipment and braking power, using the complete train of 12 cars and locomotive, and also in 12 car breakaway stops. The clasp brake rigging was tested in single car breakaway tests only, there being but one of the test cars equipped with this type of rigging. Therefore, in comparing the different types of rigging it will be necessary to make the comparisons accordingly so far as the actual stops are concerned, although a method has been developed whereby the probable stop of a complete train can be computed with what is believed to be reasonable accuracy.

On account of the many different conditions of air brake equipment, per cent of braking power, and manipulation used with the different types of brake rigging, it is necessary to choose arbitrarily some representative combination of these factors and compare the different riggings all on the same basis. For this purpose the best available records are those of the so-called check runs, namely, emergency stops made at 60 m.p.h. with the complete train of 12 cars and locomotive using the electro-pneumatic air brake equipment and 150 per cent nominal braking power, and the breakaway stops under similar conditions.

TABLE 1 EMERGENCY STOPS 60 M.P.H. WITH ELECTRO-PNEUMATIC BRAKE, 150 PER CENT NOMINAL BRAKING POWER

Kind of Brake Rigging	Kind of Stop	Stop Distance in Ft.			Average Braking Power, Train	Per Cent Braking Power per Lb. Cylinder Pressure, Cars
		Average	Maximum	Minimum		
Standard	Train	1160	1298	1049	133	1.473
	12 car breakaway	1228	1291	1178	143	1.473
No. 1 clasp	Train	1204	1273	1157	135	1.499
	12 car breakaway	1145	1183	1112	148	1.499
No. 2 clasp	Train	1145	1213	1097	134	1.450
	12 car breakaway	1136	1178	1073	141	1.450
No. 2 clasp	Single car breakaway	1014	1027	1007	140	1.430
No. 3 clasp	Single car breakaway	924	1010	873	149	1.505

Table 1 gives average results and in preparing it tests were not considered in which the stops were influenced by conditions other than the action of the brake rigging.

Inspection of the table shows that the per cent braking power varied somewhat from the different types of rigging tested. This variation, so far as the difference between train and breakaway is concerned, necessarily follows from the effect of the lower braked locomotive.

Comparing the braking powers for the train using the No. 1 clasp, the standard, and the No. 2 clasp brake and for the 12 car breakaway stops with these types of rigging it will be seen that the variation is not sufficient to materially affect the average results obtained.

The No. 3 design of clasp brake was tried on a single car only. Consequently its performance has to be compared with that of the No. 2 clasp brake on a single car. The braking power per pound of brake cylinder pressure for the No. 3 clasp brake was higher than that of the car having the No. 2 clasp brake as shown in the table and due allowance must be made for this, but after making due allowance, the stops with the No. 3 clasp brake are still materially shorter than corresponding stops with the No. 2 clasp brake.

To sum up, therefore, the relative performance of the several different types of rigging tested on the basis of stopping distance alone, would on the whole be arranged in the following order: Best, the No. 3 clasp brake; next, the two experimental designs of clasp brake, Nos. 1 and 2, and lastly the single shoe brake.

A device used to measure the efficiencies of the brake rigging tested consisted of a steel ball and plate of known hardness located in the brake rigging as near the shoe as possible so that the force transmitted by the

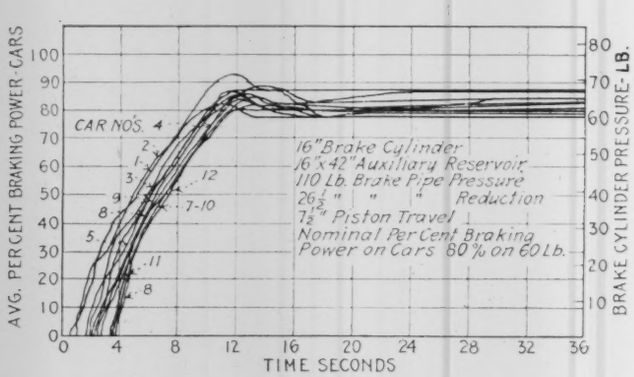


FIG. 13 CURVES SHOWING RATE OF BUILDING UP OF BRAKE CYLINDER PRESSURE IN A FULL SERVICE APPLICATION, PM EQUIPMENT

brake rigging passed through the ball to the plate on its way to the brake shoe. The diameter of the impression was measured with a micrometer microscope and the corresponding pressure determined from a calibration curve of similar impressions made under direct known pressure on a testing machine.

The ratio of the pressure at the brake shoe as found by this method, to the brake shoe pressure which should result from the cylinder pressure and the total lever ratio known to exist, represents the mechanical efficiency of the rigging in per cent.

Tests of this character were made both when the cars were running and standing, but on account of the disturbing influences encountered during the running tests, it was decided to consider only the standing tests, for which the data obtained were more consistent. It should be understood, however, that the efficiency of the transmission of the forces through the brake rigging when making a stop was considerably different than when a standing brake application is made, due to the different positions assumed by the brake shoes and levers, caused by pulling down truck spring and increase of piston travel.

With the standard brake rigging considerable binding took place in the measuring device which affected the accuracy of the readings and is probably one of the causes of the low efficiency shown. With the other types of brake rigging, however, the results were remarkably consistent. In fact, by the aid of these records, it became possible for the first time to fix upon a logical basis for harmonizing the results obtained in road tests with those obtained in laboratory tests of brake shoes.

PISTON TRAVEL

One of the factors, affecting the brake rigging efficiency, which was given particular attention, was the variations in piston travel with different cylinder pres-

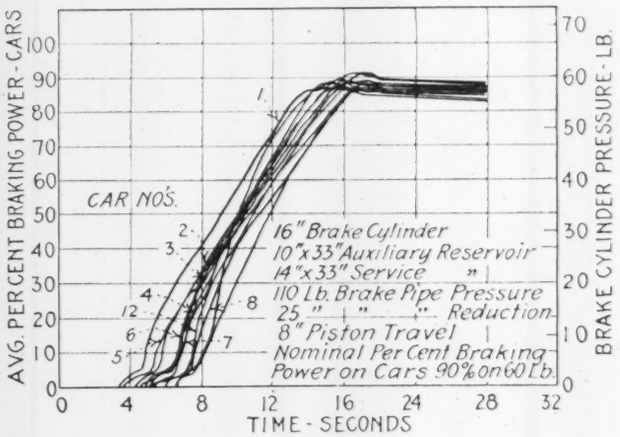


FIG. 14 CURVES SHOWING RATE OF BUILDING UP OF BRAKE CYLINDER PRESSURE IN A FULL SERVICE APPLICATION, UC PNEUMATIC EQUIPMENT

sures. Records were taken of the length of piston travel on a time basis and of brake cylinder pressures and these records were combined to form the brake cylinder pressure piston travel curves.

Referring to the increase in running emergency piston travel over standing service for the different types of rigging tested and at various percentages of braking power, it is to be noted that the increase for the No. 1 and No. 3 clasp brake is less than for either the standard or the No. 2 clasp brake, due in part, at least, to the low hung brake shoes of the latter.

IV. PER CENT OF BRAKING POWER

Definition. The total brake shoe pressure to be provided by a steam road passenger brake installation is determined according to the empty weight of the car. For convenience the pressure afforded by a full service application of the brakes is chosen as the basis upon which different installations are classified and (also for convenience) the total brake shoe pressure is usually

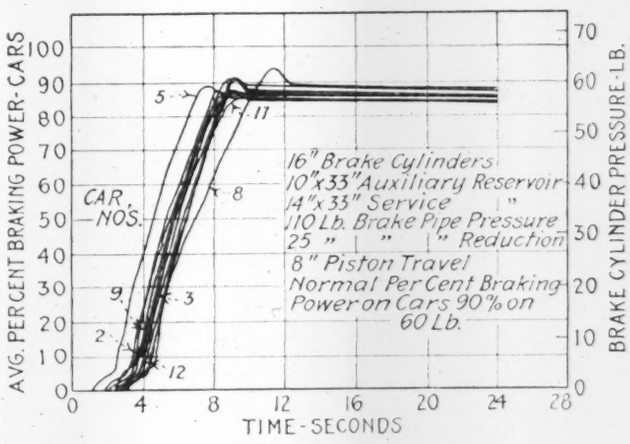


Fig. 15 Curves showing Rate of Building Up of Brake Cylinder Pressure in a Full Service Application, UC Electro-Pneumatic Equipment

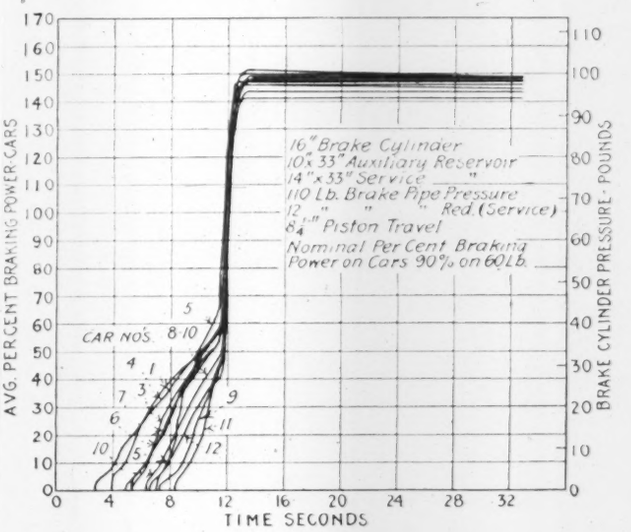


Fig. 17 Curves showing Rate of Building Up of Brake Cylinder Pressure in a Partial Service Followed by an Emergency Application, UC Pneumatic Equipment

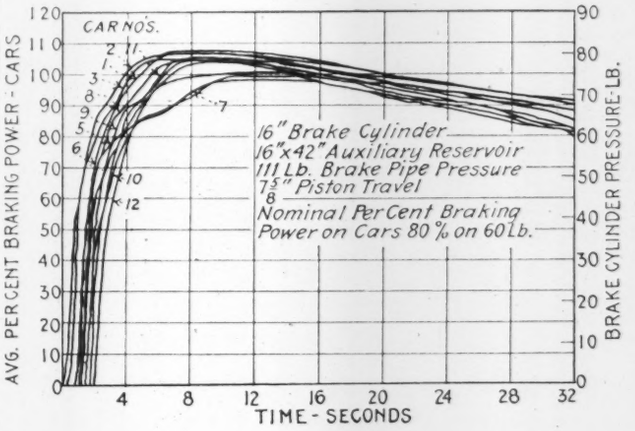


Fig. 19 Curves showing Rate of Building Up of Brake Cylinder Pressure in an Emergency Application, PM Equipment

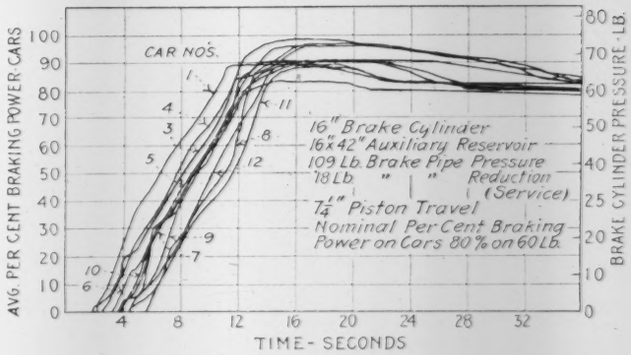


Fig. 16 Curves showing Rate of Building Up of Brake Cylinder Pressure in a Partial Service Followed by an Emergency Application, PM Equipment

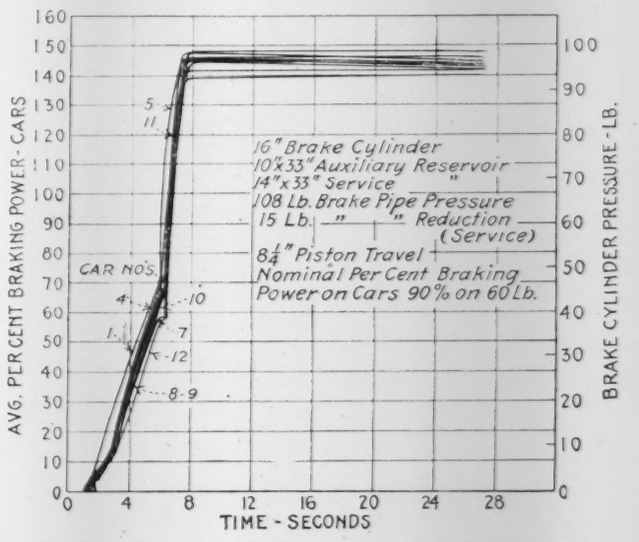


Fig. 18 Curves showing Rate of Building Up of Brake Cylinder Pressure in a Partial Service Followed by an Emergency Application, UC Electro-Pneumatic Equipment

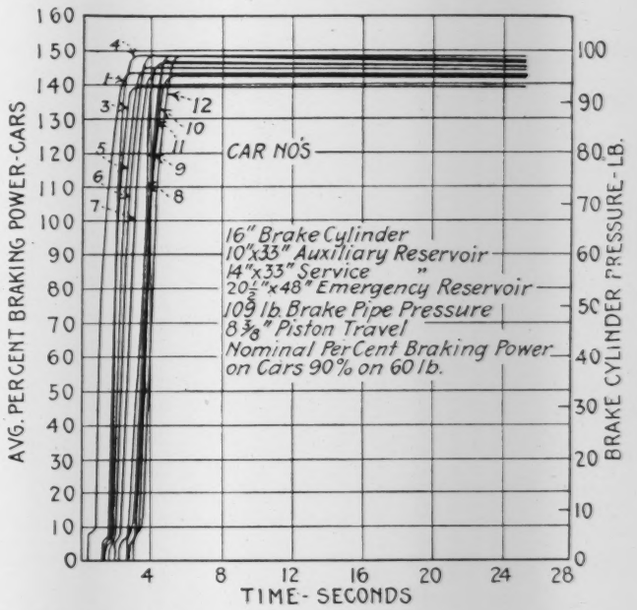


Fig. 20 Curves showing Rate of Building Up of Brake Cylinder Pressure in an Emergency Application, UC Pneumatic Equipment

expressed in terms of its ratio to the empty weight of the car. The ratio of total brake shoe pressure to total car weight has always been termed "braking power" and is usually expressed as "per cent braking power."

It has been common practice to design steam road passenger brake installations to produce a full service nominal braking power of 80 or 90 per cent; the braking power obtained in emergency applications will then depend upon the characteristics of the installation. In the case of the P. R. R. P-70 cars with standard PM brake equipment the standard nominal braking power is 80 per cent. In emergency application nominal 113 per cent braking power is figured upon, but in practice less than this is always obtained, due to the characteristics of the PM equipment whereby the maximum brake cylinder pressure is diminished by the action of the high-speed reducing valve, the effect of excessive piston travel and so on.

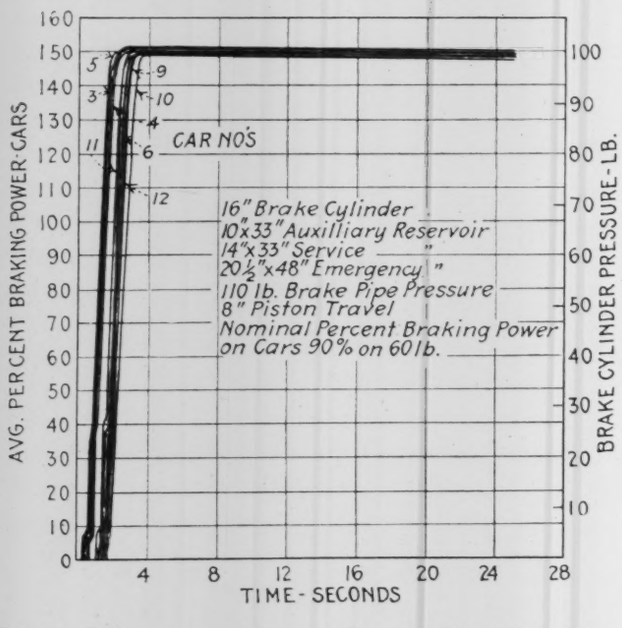


FIG. 21 CURVES SHOWING RATE OF BUILDING UP OF BRAKE CYLINDER PRESSURE IN AN EMERGENCY APPLICATION WITH IMPROVED UNIVERSAL VALVE, UC PNEUMATIC EQUIPMENT

With the improved brake equipment the standard nominal braking power is 90 per cent. This, although 10 per cent higher than standard with PM equipment, is associated with a smaller size auxiliary reservoir which results in a slower rate of increase in braking power during the progress of a service application of the brakes. This affords greater flexibility in the manipulation of the brake in service and at the same time makes available a higher maximum service braking power. In emergency stops braking powers ranging from 90 to 180 per cent were employed.

LENGTH OF STOP

The curves, Fig. 23, show the relation between the percentage of braking power and the length of stop, other factors being substantially constant. The curves are plotted for single-car breakaway stops from 60 m.p.h. with the No. 3 clasp brake, electro-pneumatic air brake equipment, plain brake shoes well worn in and cracked.

Taking from these curves the stop at 90 per cent as the basis, the stop at 125 per cent is 17.5 per cent shorter, that at 150 per cent braking power 25.5 per cent shorter, and that at 180 per cent 33 per cent shorter. An interesting development from this is that for a given increase in braking power anywhere throughout the range, a constant decrease in length of stop will result, this constant decrease, however, not being equal to the corresponding increase in braking power. For example, an increase of 25 per cent in braking power (from 90 up to 112.5 per cent braking power) results in a decrease of about 12 per cent in the length of stop (from 1177 ft. to 1033 ft.). Similarly, a 25 per cent increase in braking power, from 144 up to 180 per cent, results in the same proportionate decrease in length of stop, viz.: from 896 ft. to 787 ft., which is a 12 per cent decrease, as at the lower braking power.

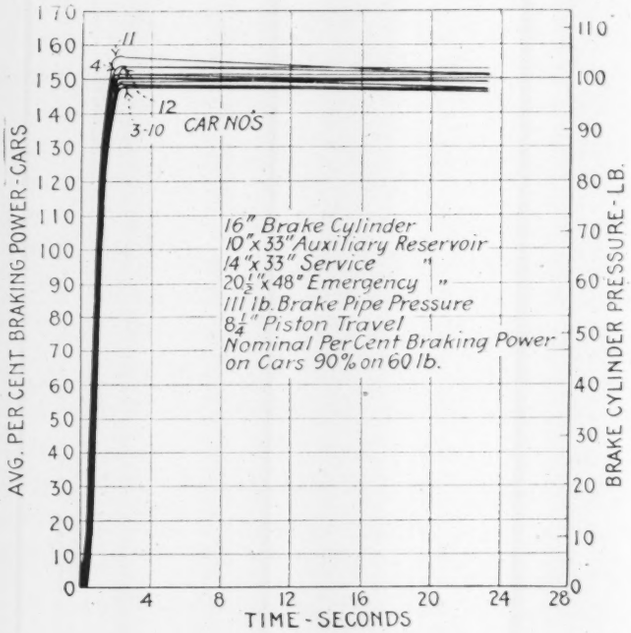


FIG. 22 CURVES SHOWING RATE OF BUILDING UP OF BRAKE CYLINDER PRESSURE IN AN EMERGENCY APPLICATION, UC ELECTRO-PNEUMATIC EQUIPMENT

An analysis of the curves on Fig. 23 shows that for single car breakaway stops from a speed of 60 m.p.h., using the electro-pneumatic brake, the relation between the percentage of braking power and length of stop can be expressed by the following equation:

$$S = \frac{K}{P^x}$$

in which S = the length of stop

K = a constant determined by the character of the air brake equipment, brake shoes and brake rigging.

P = percentage of braking power corresponding to the cylinder pressure obtained.

x = a fractional exponent, depending upon the effect of the percentage of braking power on the brake rigging efficiency and the coefficient of friction of the brake shoes.

This law is found to apply to both of the curves in Fig. 23 and that it holds for still lower braking powers than here shown was proven by both road and laboratory tests at low percentages of braking power (50 to 60 per cent), the results of which satisfied the relation which had previously been found to exist between stops under similar conditions, but at percentages of braking power ranging between 90 per cent and 180 per cent. Manifestly, however, this law could not hold at very low percentages of braking power.

Referring to Fig. 23 the equation for the line showing the best 60 m.p.h. stop is

$$S = \frac{1107.5}{P^{0.581}}$$

and for the line showing the average 60 miles per hour stops

$$S = \frac{1169.2}{P^{0.583}}$$

An approximate expression for the variation of percentage of braking power and length of stop with the electro-pneumatic equipment, is that, for an increase of 5 per cent in the braking power, the stop is decreased 2 per cent.

The above equations correspond to the theoretical relations which result from a consideration of the primary factors involved. Neglecting air and internal resistance on the one hand and the rotative energy of the wheels and axles on the other hand and considering the stop to be made on a straight level track, we have, for the portion of the stops that the brakes can be considered fully applied

$$FS_2 = \tfrac{1}{2}\frac{W}{g}v^2$$

$$PWefS_2 = \frac{Wv^2}{2g}$$

$$S_2 = \frac{v^2}{2gPef}$$

or

$$S_2 = \frac{0.0334V^2}{Pef} = \frac{V^2}{30Pef}$$

in which

F = total retarding force in lb.

S_2 = that portion of the stop in ft. during which the brakes can be considered fully applied

W = weight of train in lb.

v = speed of train in ft. per second

V = speed of train in miles per hour

P = nominal percentage of braking power corresponding to average brake cylinder pressure during time brakes are applied

e = efficiency of brake rigging

f = mean coefficient of brake shoe friction

g = acceleration due to gravity 32.2 ft. per sec. per sec.

For the short time t, at the commencement of the stop during which the brakes may be considered as having no effect, the distance traveled will be $S_1 = vt = 1.467\ Vt$.

The total length of stop S, is then

$$S = S_1 + S_2 = 1.467Vt + \frac{V^2}{30Pef}$$

For a given type of brake equipment and at a given speed, V and t are constants and the theoretical relation between the length of stop and percentage of braking power, other conditions being equal and as assumed above, is then

$$S = k + \frac{C}{Pef}$$

in which e, the efficiency of the brake rigging, remains practically constant throughout the range of values of P used in these tests. Let

$$\frac{C}{e} = C_1$$

f, the mean coefficient of friction, is known to decrease as P increases, other conditions being the same. It may therefore be assumed that

$$f = \frac{c}{P^z} = cP^{-z}$$

where z is less than unity.

The expression for length of stop can now be written

$$S = k + \frac{C_1}{PcP^{-z}} = k + \frac{M}{P^{1-z}} = k + \frac{M}{P^x} = \frac{M + kP^x}{P^x}$$

In this expression k is a constant term resulting from the fact that the brake applies gradually instead of instantaneously to its maximum value.

For practical purposes the formula

$$S = \frac{K}{P^x}$$

can be used as substantially the equivalent of more accurate but less simple formula, provided that the proper value of K is determined. This can be shown from the test data to be possible without involving an error of more than 2 per cent at the extremes of the range of these experiments, the error being still less at intermediate points.

In the relation $f = \frac{c}{P^z}$ the values of c and z can be evaluated from the data furnished by the curves, Fig. 23. We have

$$S = \frac{1107.5}{P^{0.581}} \text{ and also } S = \frac{K}{P^{1-z}}$$

Therefore $1\text{-}z = 0.581$ and $z = 0.419$

$$f = \frac{c}{P^z} = \frac{c}{P^{0.419}}$$

For $P = 1.5$ (60 m.p.h. stops being considered now)

we know that a fair average value for f is 0.10. Therefore

$$0.10 = \frac{c}{1.5^{0.419}}$$

for which

$$c = 0.12$$

Therefore an approximate relation between the mean coefficient of brake shoe friction and per cent braking power, resulting from the data of these tests (and applies therefore only to the range covered by these tests) for speeds of 60 m.p.h. plain cast iron brake shoes, clasp brake rigging, is

$$f = \frac{0.12}{P^{0.419}}$$

WHEEL SLIDING

Tests were considered as having excessive wheel sliding when the sum of all slides was 3000 ft. or over in 12 car train tests and 250 ft. in single car tests. These arbitrary figures were chosen when an analysis of the wheel sliding data developed that the sum of all slides, when less than 3000 ft. was not sufficient to have any material effect on the length of stop and was usually made up of relatively short slides on a number of pairs of wheels, but when more than 3000 ft. several pairs of wheels usually slid for the greater part of the stopping distance, making the sum of all slides well above this figure. Slides under 15 ft. were not recorded.

With the No. 1 clasp brake, wheel sliding occurred at low as well as at high percentages of emergency braking power. These tests, however, were run between February 10 and March 5 when there was a comparatively low prevailing air temperature which, with the high humidity characteristic of the locality brought about an adverse rail condition. The bad rail condition was especially marked in the first tests of the day which, with few exceptions, were electro-pneumatic emergency applications at 150 per cent braking power.

Out of a total of 90 emergency tests at 150 per cent braking power made with the No. 1 clasp brake, 62 tests developed no wheel sliding at all. Of the 28 in which there was wheel sliding, 13 were the first runs of the day, previous to which there was a period of two hours when the track had not been run over by other trains. This permitted an accumulation of frost or moisture on the rail during that interval. Few tests, made subsequent to the first run of the day, showed excessive wheel sliding, and it may be concluded that the rail condition referred to was chiefly responsible for the sliding that occurred.

The tests with the other types of brake were made later in the spring when the weather was more favorable to good rail condition, and that in these tests there is a marked decrease in excessive wheel sliding.

An analysis of the percentage of runs with wheel sliding at various percentages of braking power shows that with plain shoes the amount of wheel sliding depends rather on the rail and weather conditions than on the percentage of braking power.

A total of 282 emergency tests at 150 per cent braking power were made with the various types of brakes; of this number 22 per cent had wheel sliding, 10 per cent occurring during the tests of the No. 1 clasp brake.

At 180 per cent braking power with plain shoes, wheel sliding occurred on but 7 out of 36 tests. With flange shoes sliding occurred in 11 out of 23 tests. In only one test of the 59, with 180 per cent braking power, was there wheel sliding amounting to over 3000 ft.

From the above it follows, that the determining factor in wheel sliding is not high braking power alone but rather the uncontrollable conditions of rail and weather in connection with it, against which no permanent provision can be made without a sacrifice in the length of emergency stops during those favorable periods of the day or seasons of the year when conditions warrant the use of high braking power.

Whether the sliding of wheels will or will not cause flat spots of a size sufficient to produce rough riding of the car depends entirely on circumstances; for example, a condition of rail surface which will cause a considerable amount of wheel sliding, with relatively low percentages of braking power, is a condition which at the same time will permit long slides to occur without producing noticeable flat spots. On the other hand, when the rail is in good condition, or in the extreme case of a sanded rail, a very short slide may produce flat spots of a size requiring prompt attention. No flat spots were obtained of sufficient size to necessitate changing wheels during the tests, although, on account of the number of small spots accumulated upon the wheel tread, it was found advisable to change some wheels before the cars were put back into regular service.

COEFFICIENT OF RAIL FRICTION

In determining the coefficient of rail friction by use of the rail-friction machine, the same section of rail was used at all times. The kinetic coefficient of friction, or the ratio of the force required to keep the weights moving slowly and the pressure of these weights upon the rail, was found to give more consistent readings than observations of the "static" coefficient.

The kinetic values determined range between 12 and 35 per cent, with the great majority of readings ranging between 22 and 30 per cent. The records, when taken in connection with simultaneous readings of air temperature and relative humidity, show that the coefficient of rail friction decreases with an increase in the relative humidity for temperatures below the freezing point, whereas the coefficient of rail friction is not greatly affected by high humidities as long as the temperature is high, but begins to fall as the temperature approaches the freezing point.

As an interesting study of the effects of these various factors, consecutive observations were taken of the coefficient of rail friction, air temperature, relative humidity and barometric pressure for a period of twenty-four hours. It is significant that the coefficient of rail friction obtained on the first reading in the early morning was practically the same as that found for a *well greased rail* later in the day.

There was no great consistency between the readings obtained for coefficient of rail friction and the amount of wheel sliding experienced. While as a rule the greatest amount of wheel sliding occurred during the first runs of the morning, at which time the coefficient of rail friction was usually low, it was also a fact that occasionally considerable wheel sliding would be experienced when the coefficient of rail friction observed previous to such tests had been about at its average value.

This led to the conclusion that other factors, such as shock, slack action, and foreign matter on the rail surface, have a controlling influence in causing wheel sliding.

Tests were made of the experimental device that was applied to the locomotive to give a higher maximum emergency braking power in a shorter time than is obtained with the standard ET equipment, in order to overcome the shock resulting from the maximum emergency braking power on the cars being higher and much more quickly obtained than that on the locomotive.

Comparative car and tender brake cylinder cards and slack action diagrams for 60 m.p.h. emergency stops, electro-pneumatic equipment, 150 per cent braking power on cars, with and without the higher braking power on the locomotive, shows that the sudden and considerable slack action on the records taken between cars 1 and 2, indicating the shock received at the draft gears about two seconds after the brakes are applied is much less severe when the locomotive is braked higher than normally. The result is a comparatively slow relative movement between cars, which is not noticeable to passengers.

V. GENERAL DISCUSSION OF STOPS

The shortest 60 m.p.h. emergency stop was made with a single car (locomotive not attached) with the No. 3 clasp brake electro-pneumatic equipment, 180 per cent braking power, and flanged brake shoes. The car was stopped under these conditions in 725 ft. The average retarding force for this test was 332 lb. per ton. This is equivalent to the resistance offered by a 16.6 per cent grade on which one end of a P-70 car (80 ft. long) would be 13.3 ft. higher than the other end.

This stop of 725 ft. from 60 m.p.h. made with a modern heavy passenger equipment car establishes a new record for a railway car stop.

Assuming a rail adhesion of 25 per cent, the shortest possible stop which could be obtained, by utilizing this adhesion to its maximum throughout the period of braking, would be 481 ft. This would require an ideal brake shoe and a controlling mechanism which would automatically adjust the retarding force of the brake, so that it would be at all times the maximum which could be used just short of producing wheel sliding.

The shortest 80 m.p.h. stop was made, with conditions the same as mentioned above, in 1422 ft. This is equivalent to an average retarding force of 310 lb. per ton.

From the data of stops made with locomotive alone and single car breakaway stops it is possible to calculate the approximate length of stop which would be obtained with a locomotive and train of twelve cars equipped with the electro-pneumatic brake.

Calculated from the results of single car breakaway tests, the best 60 m.p.h. train stop that could have been obtained with the means available during these tests is about 800 ft. and the best 80 m.p.h. stop about 1570 ft.

The shortest 60 m.p.h. train stop with a locomotive and train of twelve cars was 1021 ft. This was made with high braking power on the locomotive and No. 1 clasp brake, electro-pneumatic equipment, 180 per cent braking power and plain shoes on the cars.

The shortest 80 m.p.h. train stop was made in 2197 ft. with high braking power on the locomotive and with No. 1 clasp brake, electro-pneumatic equipment, 150 per cent braking power and plain shoes.

CHECK RUNS AND AVERAGES

In previous brake tests the average of two, or at the most three, stops under a particular set of conditions was thought sufficient to establish the average performance of the train, but a study of the situation revealed many variations in performance which could not be accounted for by any known differences in the equipment, adjustment, or manipulation. In order to determine the amount and cause of such variable performances as might result under supposedly constant conditions, a series of so called check runs was scheduled, one test to be made at the beginning and another at the end of each day's work, all conditions being kept the same throughout the entire series of tests as far as possible. These stops were all made from a speed of 60 m.p.h with the complete train, standard braking power on the locomotive, electro-pneumatic equipment, 150 per cent braking power, and plain shoes on the cars.

It was observed that after the brake shoes were well worn in and no change was made in apparatus or manipulation for a considerable period of time the check runs of such a group of tests would show but little variation (for example five such tests averaged 1181 ft., with a maximum only 8 ft. longer and a minimum only 11 ft. shorter than the average). However, when any change was made, such as in locomotives used, in per cent braking power of locomotive and tender, or

in brake shoes such as the replacement of a number of worn shoes by new ones, or the gradual wearing in of the brake shoes on the whole train, during the early part of a new series of tests, the length of stop obtained would vary, showing that the effect of new factors so introduced might be considerable.

The results of the complete series of check runs indicated that the variations are unavoidable, except by the most careful provision for the constancy of all factors which have an effect on the stop. The brake shoe bearing is the most difficult factor to control and at the same time it is the most potent in producing variations in brake performance.

An example of the importance of the brake shoe condition and the manner in which it can be affected was

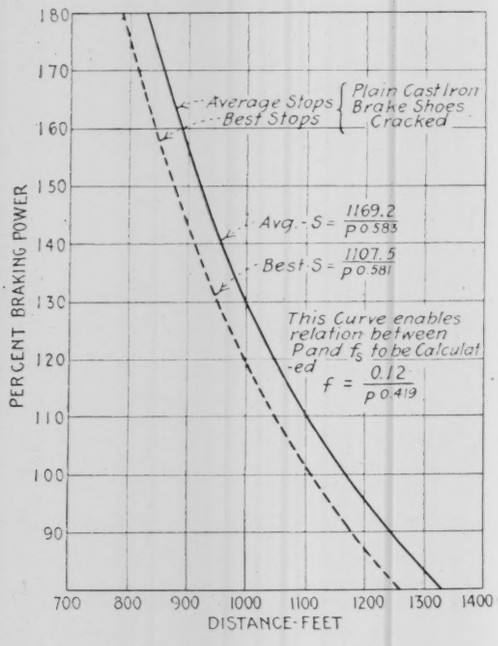


FIG. 23 CURVES SHOWING LENGTHS OF STOP IN SINGLE CAR EMERGENCY BREAKAWAY STOPS MADE WITH NO. 3 CLASP BRAKE, FROM 60 M.P.H. WITH THE ELECTRO-PNEUMATIC EQUIPMENT

afforded by one of the check runs with the standard (single shoe) brake rigging. This stop of 1049 ft. was the shortest 60 m.p.h. *train stop* actually made with 150 per cent braking power. Had the cars been stopped alone, i.e., without the locomotive, this stop would have been approximately 960 ft. This was not only the shortest stop made with this train, but was shorter than any check run with trains equipped with clasp brake rigging. It was made under peculiarly favorable conditions; while it was the first run of the day, the rail condition was good and the test followed nine tests at a low (90 per cent) braking power which insured the best possible shoe bearing. The favorable shoe bearing was further contributed to by the light service applications made during the movement of the train from and to the test ground and by the standing of the train over night.

On the other hand the *longest stops* of the check runs with any arrangement of brake rigging were also made with *this same train* (single shoe rigging), under identical conditions so far as could be provided, of air brake mechanism, brake rigging and all other controllable factors, but after the shoe conditions became unsatisfactory, due to many shoes running partially off the wheel. Three such stops were 1359 ft., 1361 ft., and 1389 ft, respectively from 60 m.p.h., or over 300 ft. longer than the short stops mentioned in the preceding paragraph. This shows that for a constant set of conditions (other than that of the brake shoes) the shortest and also the longest stops of the entire series of comparative tests were brought about by variations in brake shoe condition alone.

TESTS WITH NO. 3 CLASP BRAKE ON SINGLE CAR

The No. 3 clasp brake was applied to but one car and in making tests this car was separated from the locomotive before reaching the point on the test track at which the brakes were automatically applied, so that the stop of the car alone might be observed. This afforded an opportunity for controlling the conditions and insuring a freedom from influences other than those under investigation or beyond control which is attainable to a very much less degree in making breakaway stops with a number of cars and to a still less degree when making stops with a complete train of locomotive and cars. On the other hand, however, the fact that the individual cars necessarily differ in performance must not be overlooked, and the performance of a single car cannot be accepted unreservedly unless it is known that the car tested is fairly representative in every way of all cars in its class.

In studying the stops made with the No. 3 clasp brake, the distance of the stop being plotted against the actual per cent braking power realized, calculated from the brake cylinder pressure observed for each test, there was again shown a variation in length of stop of *nearly 300 ft.*, which can be attributed to variable brake shoe action alone, since other conditions were maintained substantially consistent. An important consideration in this connection is that this variation occurred when even the longest of the stops were themselves relatively short. This is a condition that renders any further shortening of the stopping distance by any of the means *within control of the designer*, an exceedingly difficult task.

GENERAL COMPARISONS OF STOP

Figs. 24-26 are chosen from the large number of similar comparisons contained in the complete report to illustrate how the data obtained permits of making a great variety of comparisons, according to the kind of comparative data desired. The diagrams are self ex-

planatory, showing average results expressed in terms of the length of the stop under different conditions of train make-up, air brake equipment on cars and locomotive, kind of brake application, per cent of braking power, type of brake rigging, type of brake shoes, and speed.

Certain variables were encountered during different tests which were found to have more or less effect on the comparative value of the averages. As there was no satisfactory means for compensating for these variables, however, such averages as are so affected have been classified as follows:

(1) Car stop affected by locomotive.

(2) Braking power decidedly lower than tests of other brake rigging or of the same brake rigging at other speeds, with the same air brake equipment.

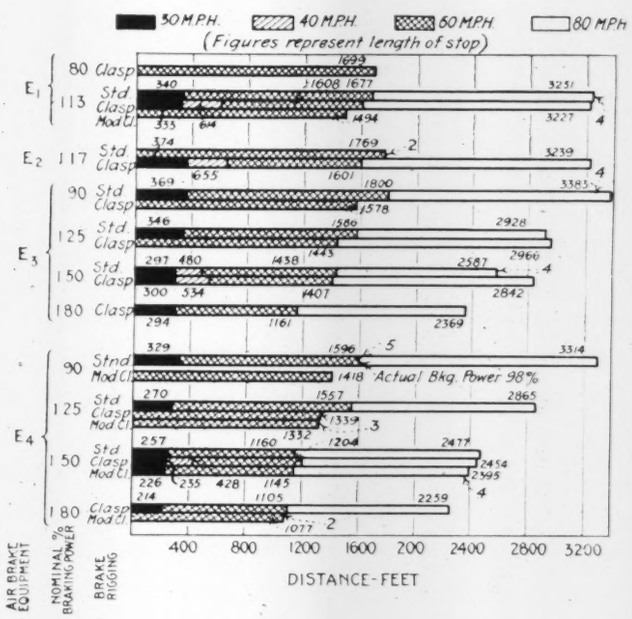


Fig. 24 Comparisons of Emergency Stops with Various Equipments and Nominal Percentages of Braking Power

(3) Braking power decidedly higher than on tests of other brake rigging or of the same brake rigging at other speeds, with the same air brake equipment.

(4) Speed 4 m.p.h. or more, less than nominal.

(5) Bad shoe condition.

COMPARISONS BETWEEN SINGLE CAR AND 12-CAR TRAINS

In making comparisons of the effects of the various percentages of braking power on the length of stop of the complete train of locomotive and 12 cars it should be remembered that the nominal per cent braking power (unless qualified) represents the braking power of the cars. In train tests, due to lower braking power of the locomotive and tender, the per cent braking power of the train, as a whole, is somewhat reduced.

For example with a K locomotive and tender half loaded the following table shows the braking power of the cars and of the train as a whole:

Twelve Cars	Twelve Cars and K Locomotive (Tender half loaded)
90 per cent	90 per cent
113 " "	100 " "
125 " "	117 " "
150 " "	137 " "
180 " "	160 " "

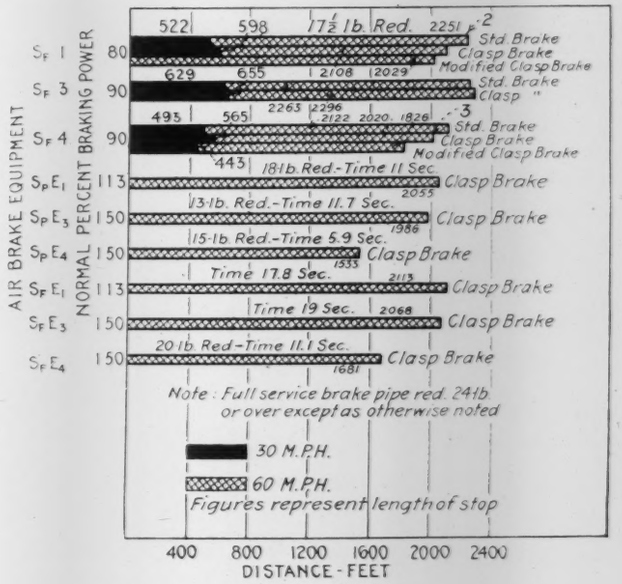


Fig. 25 Comparisons of Service Stops, and both Partial and Full Service Applications, Followed by Emergency, with Various Air Brake Equipments

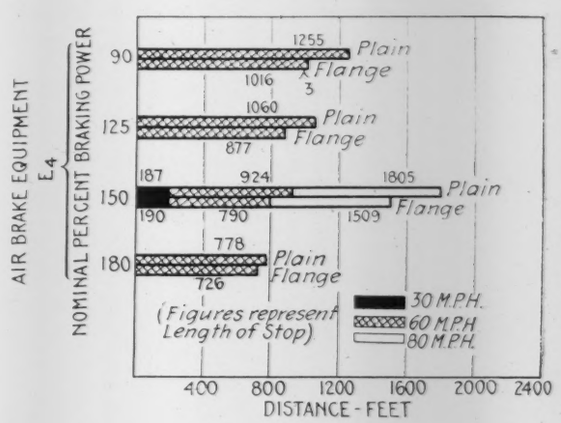


Fig. 26 Comparisons of Single Car Emergency Breakaway Stops with Various Nominal Percentages of Braking Power

The load on the tender was observed for each test, and due allowance was made for this in calculating the per cent braking power based on the actual brake cylinder pressure obtained for the entire train.

Figs. 27 and 28 illustrate the characteristic change

in length of stop for different initial speeds of the train, other conditions being substantially standard. Fig. 27 shows the average results obtained with locomotive and 12 car train using the ordinary standard (single shoe) brake rigging, electro-pneumatic air brake equipment and ordinary unflanged brake shoes with various percentages of braking power on the cars.

The curves shown for train stops from various speeds with the No. 3 clasp brake (Fig. 28) have been derived from the single car stops by assuming that the same ratio exists between the single car and train stops with the No. 3 clasp brake as was found to exist between the single car and train stops of the No. 3 clasp brake. This is believed to be the best possible calculation that can be made of the probable train stops with the No. 3 clasp brake (for which only single car breakaway tests were available) which would compare with those shown in Fig. 27.

From the data of all the single car, 60 m.p.h. break-

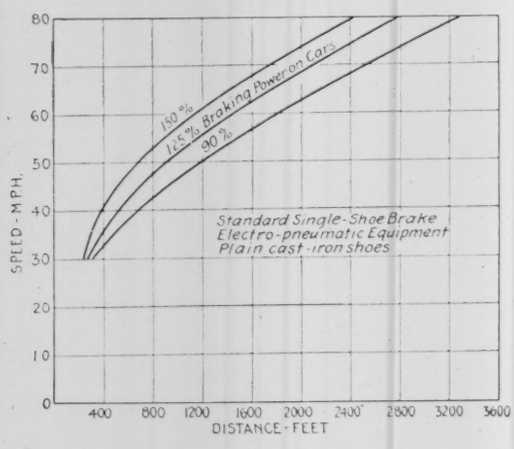


FIG. 27 COMPARISON OF FULL TRAIN EMERGENCY STOPS, FROM VARIOUS SPEEDS AND PERCENTAGES OF BRAKING POWER, STANDARD SINGLE SHOE BRAKE

away stops, the curves of Fig. 29 have been plotted to show not only the observed relation between the length of stop and per cent braking power but also how this relation changed for different types of brake shoes and brake rigging tested and again, according to whether the several best or the average of all fairly comparative stops were considered.

ESTIMATED TRAIN STOPS, NO. 3 CLASP BRAKE

The various types of car brake rigging used during the tests were applied to the 12 cars of the test trains, with the exception of the No. 3 clasp brake rigging. The No. 3 clasp brake was applied to but one car and all tests made in connection with this rigging were single car breakaway stops. In order to make the data of these tests comparable with the tests of other types of brake rigging it would be necessary to compute the probable 12 car train stops of the No. 3 clasp brake from the data of the actual single car breakaway stops. With this object in view a series of separate locomotive tests were made in order to determine accurately the performance of the locomotive.

When the electro-pneumatic equipment is used the probable stop of a train of any number of cars and locomotive may be calculated from the following approximate formula, when the length of stop and weight of a single car and of the locomotive are separately known. This method does not take into account the difference between the time elements of the brake action on the locomotive and on the cars, which, however, is very small with this equipment, its effect amounting to about three ft. in the computation of a 1000-ft. stop.

$$S_t = \frac{W_t S_1 S_c}{S_c W_1 + N S_1 W_c}$$

Where W_t = weight of train, locomotive and cars in lb.

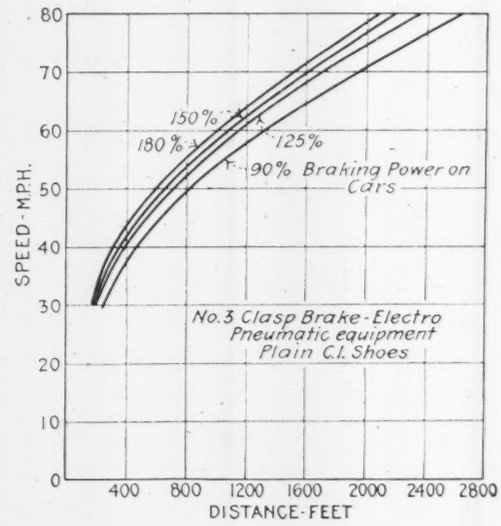


FIG. 28 COMPARISON OF FULL TRAIN EMERGENCY STOPS FROM VARIOUS SPEEDS AND PERCENTAGES OF BRAKING POWER, NO. 3 CLASP BRAKE

W_1 = weight of locomotive in lb.
W_c = weight of a single car in lb.
S_t = length of stop of train in ft.
S_c = length of stop of a single car in ft.
S_1 = length of stop of locomotive in ft.

It will be noted that by means of the above formula a 12 car and locomotive train stop can be computed for any initial speed, provided the necessary single car and separate locomotive test data are known for the same speed.

For example, from the data of the best stops with the No. 3 clasp brake, flanged shoes, single car breakaway tests, we have:

W_c = weight of car = 125,200 lb.
$12W_c$ = 1,502,400 lb.
W_1 = weight of locomotive = 414,800 lb.
$W_t = W_1 + 12\,W_c$ = 1,917,200 lb.
S_1 = 1552 ft., stopping distance of locomotive alone from a speed of 60 m.p.h.

S_c = 991 ft., stopping distance of single car alone at 90 per cent braking power from a speed of 60 m.p.h.

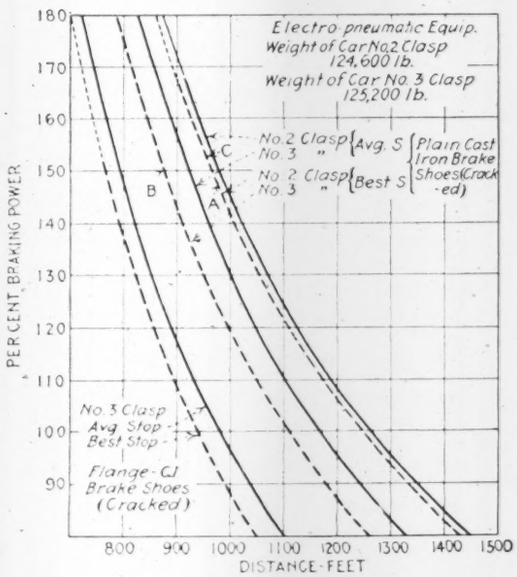


FIG. 29 COMPARISON OF SINGLE CAR BREAKAWAY STOPS FROM 60 M.P.H. AT VARIOUS PERCENTAGES OF BRAKING POWER

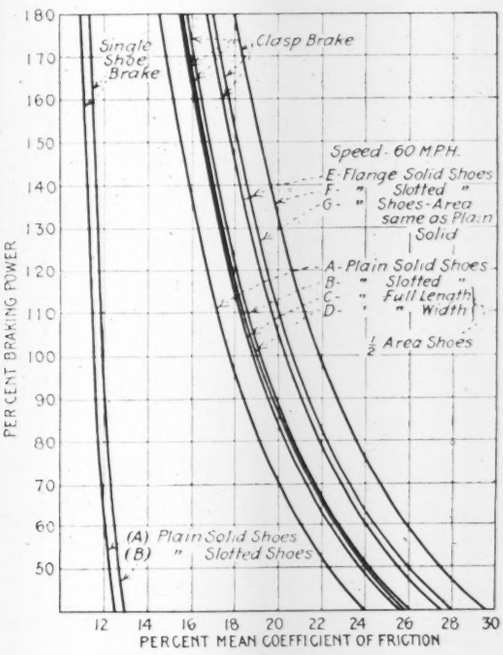


FIG. 31 CURVES SHOWING MEAN COEFFICIENT OF FRICTION ON TESTING MACHINE AT DIFFERENT BRAKING POWERS

Substituting these values in the following expression

$$S_t = \frac{W_t S_c S_1}{S_c W_1 + S_1 \ 12 W_c}$$

we have $$S_t = \frac{1{,}917{,}200 \times 991 \times 1552}{991 \times 414{,}800 + 1552 \times 1{,}502{,}400}$$

$$S_t = 1075 \text{ ft.}$$

Where the special high-pressure emergency bypass valve was used with the ET equipment on the locomotive, a shorter stop was obtained and in order to work out the train stop according to the above formula

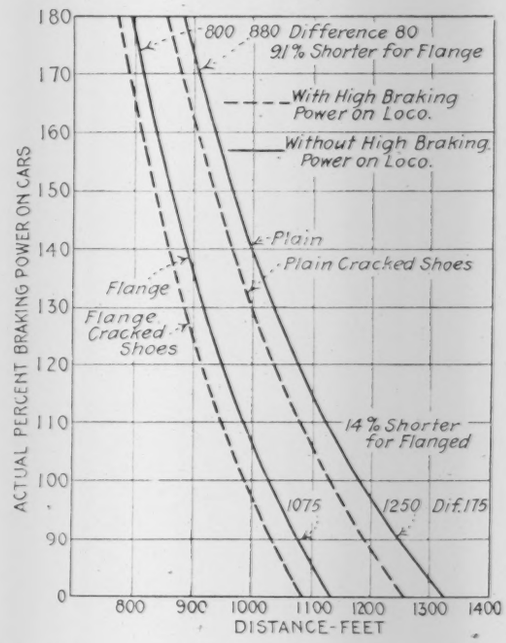


FIG. 30 COMPUTED TRAIN STOPS BASED ON BEST SINGLE CAR STOPS WITH NO. 3 CLASP BRAKE

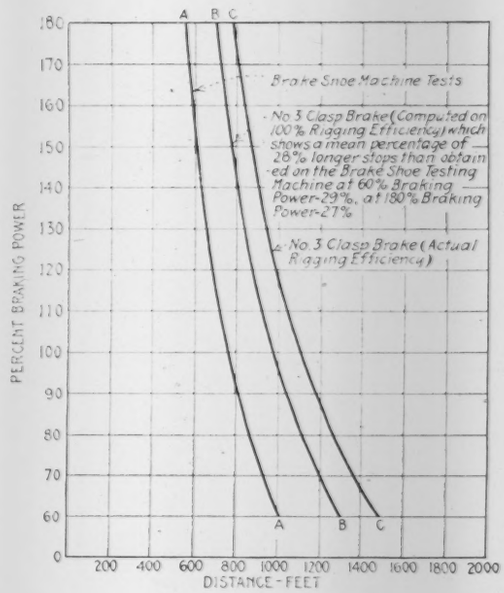


FIG. 32 CURVES SHOWING RELATION OF MACHINE TO ROAD TESTS

for this condition it would be necessary to substitute for the value of S_1 = 1552 ft., the value of S_1 = 1228 ft., which was the average stopping distance of the locomotive from a speed of 60 m.p.h. when using the special high-pressure emergency bypass valve.

The data of the best single car breakaway stops made with the No. 3 clasp brake from a speed of 60 m.p.h. at

various percentages of braking power, with both plain cracked and flanged cracked shoes, are shown in Fig. 29. Using these data as a basis and combining with them the data of the separate locomotive tests, complete train stops were computed as described and have been plotted in Fig. 30. It will be noted that for each type of shoe two curves are shown. In each case the dotted and solid lines represent the train stops which would be obtained if the locomotive were operated respectively with or without the special high-pressure emergency bypass valve.

Fig. 30 is also of interest in that it shows the gain from the use of flanged instead of unflanged shoes. The best single car breakaway stop with flanged shoes from 60 m.p.h. and 180 per cent braking power was 725 ft. This is equivalent to a 12 car train stop, using the standard ET locomotive equipment, of 795 ft. (Fig. 30).

BRAKING POWER, SERIAL ACTION AND SHOCKS—LOW SPEED STOPS

There is but little on record concerning the likelihood of shocks due to a high emergency braking power quickly applied at low speeds, although the general impression is that emergency applications, even at 60 miles per hour or over, are likely to be rough or even dangerous to passengers. This is a wrong impression. It is well known to all who have observed the action of brakes at high speeds (and it was the invariable experience during these tests) that the higher the speed the less noticeable is the application of the brakes.

The use of the UC pneumatic and electro-pneumatic equipments at the same speeds, percentages of braking power and otherwise similar circumstances, afforded an opportunity to demonstrate the most important fact in this connection, namely, that the amount of braking power, by itself, has but little to do with the shock experienced. The rate of transmission of serial brake application in relation to the rate of build up of brake cylinder pressure on each car or, in other words the action of the slack between the different vehicles in the train, is the controlling factor. With the electro-pneumatic brake, in which simultaneous quick action of the brakes on all vehicles is obtained, there was no shock at any speed or percentages of braking power except the slight shock on the first few cars due to the running out of slack which was to be expected on account of the relatively low braking power on the locomotive. On the other hand with the pneumatic equipment, having an appreciable time interval between the application of the successive cars in the train, shocks were experienced.

The most marked evidence of the effect of the time element in the serial action of the brakes and resultant shocks, occurred during the emergency stops made from very low speeds. In four tests made with the UC pneumatic equipment at ten and at twenty miles per hour, the resulting shocks, especially in the last third of the train, were extremely severe, being in effect a collision between the forward end of the train, which was almost stopped, and the rear end upon which the brake application was having but little, if any, effect at the time the rear end run-in occurred. The fact that this test was made with the UC pneumatic equipment, which was relatively slow in transmitting serial quick action, undoubtedly caused more severe shocks than will be experienced with the considerably smaller time element of the universal valve as subsequently modified.

That shocks disappear entirely when the time element in the application of the successive brakes in the train is eliminated was shown by repeating the 10 m.p.h. stop using the electro-pneumatic equipment. Notwithstanding that the stop was made in a shorter distance than before (37 ft., instead of 42 ft., and 45 ft. respectively), the difference in the action of the train was marked. There was no shock or violent slack action, although a very high rate of retardation was produced.

CHARACTERISTIC SPEED, RESISTANCE, DECELERATION AND POWER CURVES

During any stop the retardation at different instants is dependent upon the resultant normal pressure of the brake shoes on the wheels, the instantaneous value of the coefficient of brake shoe friction, and the effect of the air and internal resistances. The difference between the effects of the rotative energy of the wheels and the opposing air and internal resistances is relatively so small, compared with that due to the action of the brakes, that it does not require consideration here. The brake resistances increase as the brake cylinder pressure increases, during the time the brakes are being applied. After the maximum brake cylinder pressure is reached with the UC equipment, no further change in brake cylinder pressure takes place. Consequently, the resultant normal pressure is substantially constant from that point to the end of the stop. If the coefficient of brake shoe friction was constant throughout the stop, the resultant resistance and retardation would then be constant, and the speed-distance curve would be a true parabola, while the speed-time curve would be a straight line. It will be of interest to check these conclusions with the results obtained in several typical tests.

In order to study the relations of the factors above mentioned to the best advantage, typical single car breakaway stops, and stops with the locomotive alone have been chosen, which eliminates the disturbing influences of slack action (which produce apparent changes in retardation which are not characteristic of the train as a whole), the variations in the retardation on the different vehicles comprising the train (which would require the averaging of all data for all cars in

order to arrive at a satisfactory relation betweeen cause and effect), the non-uniformity of brake rigging and brake shoe conditions (which can not be as satisfactorily controlled on a train of a number of cars as on a single car) and the variable effect of the locomotive. Speed-time and speed-distance curves were plotted from the track chronograph records of the various stops chosen, and from the speed-time curve, time-deceleration and resistance curves have been plotted, the ordinate at any point on the deceleration curve being proportional to the slope of the tangent to the speed-time curve at the corresponding point.

The curves showing deceleration and resistance are not horizontal lines beyond the point where the brake becomes fully applied. The resistance is not constant but changes more or less as the speed of the train is reduced, especially toward the end of the stop, where a considerable and continual increase in retardation is experienced. As pointed out above, this occurs during the time the brake cylinder pressure is constant, and consequently the resultant normal brake shoe pressure is substantially constant. The conclusion, therefore, follows that the other factor, viz., the coefficient of brake shoe friction is changing and that the character of the changes which it undergoes is accurately portrayed by the deceleration curves derived as explained. This characteristic change in the coefficient of brake shoe friction has been a matter of common observation in every instance where train tests or laboratory tests of brake shoes have been studied from this point of view. A further analysis of the influences which bring about the characteristic variations in brake shoe friction will be found in the chapter on Brake Shoes.

Having the deceleration and resistance curve thus plotted on a time basis, the value of the resistance at different distances from the point of brake application can be determined by the aid of the speed-time and speed-distance curves. In this way, the distance-deceleration and resistance curves were plotted. The work done during any portion of the stop is proportional to the area under the distance-resistance curve.

In order to obtain the average resistance to the motion of the train, it is necessary to integrate this curve. The shape of the curve at the beginning is determined by the more or less rapid rate of rise of brake cylinder pressure, which depends upon the kind of brake equipment being used. In order to arrive at a relation between the force developed in the brake cylinder or at the brake shoe, and the resulting retarding force, it is advantageous to consider this relation from the standpoint of constant brake cylinder, or shoe pressure, throughout the stop. Consequently, it is desirable to replace the effect of the variable pressures acting during the time the brake is being applied by their equivalent effects, had the maximum pressure developed and held throughout the stop, been realized instantaneously. This can be done by determining the point of equivalent instantaneous application of retarding force, which is the point at which the maximum retarding force initially developed could have been applied instantaneously to produce the same effect on the speed of the train, as was realized from the gradual building up of retarding force that actually occurred. The amount of work required to reduce the initial speed of the train to the value which existed at the time the retarding force reached its initial maximum value, is proportional to the area under the distance-resistance curve up to this point. The same amount of work would be represented if the gradually rising resistance curve were replaced by a vertical line, representing the development of the same maximum retarding force instantly, but at a point such that the work done in the two cases is the same.

Having determined the point of equivalent instantaneous application of the retarding force, the average resistance, *during the time that the brake may be considered fully applied*, can be found by integrating the area under the entire distance-resistance curve and dividing this area by the total length of stop minus the distance from the start to the point of equivalent instantaneous application.

TABLE 2 EMERGENCY 12 CAR TRAIN STOPS FROM 60 M.P.H.

Brake Rigging	Brake Shoes	Air Brake Equipment	Nominal Braking Power	Stop	
				Best	Avg.
Standard	Plain	PM	113	1659	1677
Standard	Flanged.	PM	113	1453	1453
No. 1 clasp.	Plain	UC pneumatic	125	1405	1443
No. 2 clasp.	Plain	UC pneumatic	125	No te sts	
No. 1 clasp.	Plain	UC electro-pneumatic	125	1338	1339
No. 1 clasp.	Plain	UC electro-pneumatic	150	1157	1204
No. 2 clasp.	Plain	UC electro-pneumatic	125	1317	1332
No. 2 clasp.	Plain	UC electro-pneumatic	150	1097	1145
No. 3 clasp.	Plain	UC electro-pneumatic (estimated)	125	1055	
No. 3 clasp.	Plain	UC electro-pneumatic (estimated)	150	965	
No. 3 clasp.	Flanged.	UC electro-pneumatic (estimated)	125	935	
No. 3 clasp.	Flanged	UC electro-pneumatic (estimated)	150	860	

A SUMMARY OF GENERAL RESULTS WITH A TWELVE CAR TRAIN

Table 2, giving emergency 12 car train stops from 60 miles per hour summarizes the stops obtained during the road tests and shows briefly the gain in stopping distance to be obtained by the use of flanged shoes, clasp brakes and the UC pneumatic or electro-pneumatic equipment.

VI. BRAKE SHOES

Prior to starting the tests it was arranged to have the brake shoes made from special heats and to be as near as possible to the normal composition of standard cast iron shoes in order that the variation in brake

shoes might not affect comparisons of air brake equipment and the brake rigging. Before applying these shoes to the test train they were broken in on other trains to wear off the face surface or slight chill incident to foundry practice. When so broken in, with an average of 1/8 in. of thickness removed from the face, Brinell hardness readings of the surface were taken and the shoes grouped according to hardness numbers.

At the time of breaking-in the shoes for the test train a series of tests was made to determine the variation in hardness with respect to wear. The results of this investigation showed that when the shoe is new a wide variation in hardness may be expected between shoes made from the same heat, but that as the shoe wears down the hardness becomes fairly uniform and remains so, decreasing slightly as the shoe wears out. Although at that time no data were available, it was thought that Brinell hardness was an indication, not only of the ultimate strength of the face metal of the shoe but also was related in some way to the coefficient of friction. Later tests confirm this belief, but at this time the degree of this relation is not known. The indications are, however, that the harder the cast-iron material the lower will be the coefficient of friction and that the highest possible coefficient of friction from cast iron (at least under clasp brake conditions) is obtained with a material approaching the condition of the shoe when about three-fourths worn out and having a Brinell hardness number of about 190.

The greatest uniformity of action and the highest friction seem to be obtained when the brake shoe bearing on the wheel is best. This condition would naturally be expected to follow a series of relatively light applications in the course of which the effects of temperature in warping the shoe are kept a minimum.

It may be seen here that this most desirable condition is precisely what results from the continued use of the brakes during service stops on the road and consequently the brake shoes as worn in ordinary train service are in the most favorable condition for making short emergency stops. In the tests this condition appeared at times to have been reached after several light braking power runs. Stops following such a series of runs were then shorter than similar stops following several tests at higher braking powers, other conditions being the same. This result seemed to be most consistently obtained with the single shoe train.

The schedule of tests with the No. 3 clasp brake was arranged with this in mind, but the effect was not so noticeable in this case, there being indications that a good shoe bearing with the clasp brake might follow a small number of tests made at high braking power as well as a much larger number of tests made at lower braking power. The influence of previous tests on the shoe bearing for any particular test under consideration is so obscured by other conditions, such as the general wearing in of the shoes that necessarily results at any braking power, that the observations of the effect of the shoe dressing runs are of questionable value.

A consideration of the results of the warping of the shoe led to the conclusion that the warping could be largely eliminated by slotting or cracking the shoes so that they would be more free to conform to the contour of the wheel. As a matter of fact, this cracking takes place with either plain or flanged shoes after a number of runs have been made.

As a further study of the influence of bearing area on the performance of brake shoes, tests were made with the same shoes as in the slotted shoe tests but with the ends broken off and their area reduced by 50 per cent. The first stop was made in 1031 ft. This was almost as short as the shortest stop made under similar conditions with the full area unslotted shoes (1007 ft.). Subsequent tests with these partial area shoes resulted in stops of 1210, 1190, 1193 and 1134 ft. All of these stops were with the brake shoes at a high temperature. These results tend to confirm the conclusion that the bearing area rather than the total face area of the shoe is the important factor in brake shoe performance, and that the bearing area on the first test with half area shoes was substantially as effective as that of the full area solid shoes which were undoubtedly affected by warping to a considerably greater extent. Furthermore, the much longer distances run in the four stops following the first with the one-half area shoes demonstrated the effect of shoe temperature which was offsetting the probable tendency of the better bearing area condition originally secured as a result of the reduced warping effect.

The advantage of an increased bearing area was demonstrated beyond question by the fact that the use of flanged brake shoes after being worn to a satisfactory bearing, resulted invariably in a shorter stop than under similar conditions with unflanged shoes. The shortest stops made in the entire series of tests were with flanged brake shoes and their use shortened the stop approximately 12 per cent as compared with the best similar tests in which unflanged shoes were used under similar conditions. This comparison is illustrated graphically in Fig. 30.

Up to the time of these tests there was no definite laboratory test information which would apply to the particular braking conditions under investigation, especially with reference to the actual brake shoe performance as distinguished from the brake rigging performance. To supplement the road tests, a series of laboratory tests was carried out on the brake shoe testing machine of the American Brake Shoe and Foundry Company, at Mahwah, N. J.

A study of all the bearing area measurements leads to the conclusion that none of the values of the bearing areas determined are sufficiently accurate to establish a true relation between bearing area, pressure density and mean coefficient of friction. However, the data

are such that it is possible to conclude that *the magnitude of the bearing area does change throughout the stop* and is greatest near the end of the stop. It was noticed that the bearing area shifted; that is to say, a spot which was found in the bearing area early in the stop, was found in the non-bearing area later in the stop.

To determine the effect of bearing area upon the mean coefficient of friction, the mean value of the brake shoe bearing area throughout the stop is necessary, rather than the total and relatively high value observed after the stop. A study of the data in a general way shows that the greater the pressure per square inch of bearing area, the lower will be the mean coefficient of friction.

The temperature observations taken cannot be used to establish a definite relation between the temperature of the working metal and the mean coefficient of friction, for the actual temperatures existing *at the bearing area* were not determined. The readings evidently indicated only the temperature of that portion of the shoe surrounding the pyrometer element. If this portion of the shoe happened to be in working contact with the wheel, the temperatures would be correspondingly high, but when the bearing area shifted to some other place on the face of the shoe the pyrometer indicated merely the temperature increase due to the conduction from that part of the shoe at which the heat was being generated.

For this reason the maximum temperature readings were very erratic and it was found that the only method which would give uniform temperature readings was to allow sufficient time after an observed maximum reading to permit the heat to become uniformly distributed by conduction throughout the whole shoe. It was found that the shoe temperature thirty seconds after maximum was consistent and proportional to or a function of the initial test speed, because the total amount of energy dissipated by the shoe in any stop will be proportional to the square of the speed and while some of this energy will pass into the wheel in the form of heat and some will pass off with the sparks, a proportional amount will produce a rise in the temperature of the shoe as a whole.

However, it is not reasonable to look for evidences of the effect of the temperature of the whole brake shoe on the coefficient of friction, when it is appreciated that *the temperatures at the working surfaces greatly exceed the maximum temperatures ever reached by the shoe as a whole.* Consequently for a correct understanding of the relation between temperature and coefficient of friction it is necessary to examine minutely the phenomena which occur during the development of brake shoe friction and to study the action of the materials immediately concerned in this process.

Fig. 33, to an enlarged scale, illustrates how the slight inequalities of the two surfaces in contact can interlock and resist relative movement. If the top surface is regarded as stationary any movement of the lower surface in the direction indicated by the arrow will be resisted by a force made up of two components:

a Tearing or abrasion of some of the surface projections which are interlocked; in other words, by shearing off the interlocking projections.

b By the lifting or unlocking of some of the surface projections which would require forcing the surfaces apart against the normal pressure until the minute projections on the surface successively cleared.

In brake shoe friction the first component, namely, tearing or abrasive action between the minute interlocked portions of the bearing surfaces is the important factor. Consequently the retarding force developed bears some relation to the ultimate strength of the metal which undergoes abrasion, because the action of abrasion consists of the pulling apart, or crushing of the particles of the contact surfaces. Practically none of the abrasive action takes place on the wheel, due to the harder and tougher nature of the wheel surface and the fact that the surface of the wheel is not continuously in contact with the brake shoe while the brake

Fig. 33 Diagram of Friction between Brake Shoe and Wheel

shoe *is* in continuous contact with the wheel. Inasmuch as the tearing or abrasion of the metal particles can take place only in the thin layer of the shoe metal which is in contact with the wheel, and as the actual contact area is but a portion of the total face area of the shoe, it is evident that the generation of the retarding forces and consequent absorption of the energy of the moving train is dependent upon but a *very small quantity of brake shoe metal.*

The result of this condition is that the metal in the state of abrasion undergoes a very rapid rise in temperature; and the indications are that the temperature of the working areas of the brake shoe is changing continuously, because when one set of particles is torn off energy is dissipated in the form of heat so that the next particles to be torn off are at a higher temperature than the first. This process appears to continue until the surface of the metal in abrasion reaches such a temperature that the force required to tear the particles away is greatly reduced. The abrasive action then seems to be extremely rapid until the bearing of the shoe shifts to some other and cooler spot on its surface, not previously in the same degree of contact with the wheel. The action may then be repeated and the bearing area may thus shift from one portion of the surface to another during the stop.

Unquestionably the constantly changing temperature of the contact surface has an important relation to the force of retardation developed by the tearing down of the metal particles. The resistance due to abrasion is dependent on the ultimate strength of the cast iron. It is well established that above a critical temperature (approaching 900 deg. fahr.) the ultimate strength of cast iron decreases rapidly and that at or above red heat temperatures (1400 deg. to 1800 deg. fahr.) its ultimate strength is greatly reduced.

The force of retardation due to abrasion and the corresponding mean coefficient of friction will therefore be a function of the constantly changing, but always high, temperature of the working metal. Obviously the lower the mean temperature can be maintained, the higher will be the mean coefficient of friction as long as this average temperature is above the critical temperature at which the ultimate strength of cast iron is a maximum.

Unless the brake shoe is of such a nature or in such a condition that a large proportion of its face area is in working contact with the wheel, and remains so, the principal factor in producing high friction for any given braking condition appears to be the frequent shifting of the bearing area from the heated to the cooler spots over the face of the shoe. If a shoe has a relatively small bearing area, that cannot shift, the wheel is forced to wear the highly heated and ineffective shoe metal rapidly away, and successively exposes cooler metal, which is better able to offer resistance and absorb energy.

If the friction characteristics developed by a given brake shoe under a given combination of conditions depend, as appears probable from the foregoing considerations, upon the frequent shifting of the contact areas of the shoe surface, the instantaneous as well as the average values of the frictional resistance of the brake shoes during a stop are functions of: (*A*) The fit of the shoe to the wheel; (*B*) the flexibility of the shoe; (*C*) the available bearing area.

A The fit of the shoe to the wheel has an important influence on the facility with which the contact area can shift. If an ordinary metal brake shoe fits well, according to the ordinary understanding of this expression, it necessarily cannot bear on the wheel equally at all portions of its surface. But when wear takes place, only a comparatively small amount of metal has to be worn off the bearing spots in order to bring cooler spots into contact, and consequently a good fit of the shoe will guarantee against the possibility of the bearing area being held concentrated at any particular spots, after they have become heated to a point where the metal breaks down rapidly and offers a comparatively poor resistance.

B The effect of warping is clearly shown by the comparative performance of a solid shoe of any type and a similar shoe slotted so as to make it more flexible. In every case the slotted shoe has a decided advantage. With a warped shoe the bearing area cannot shift readily and consequently the average temperature of the working metal is high and a correspondingly low mean coefficient of friction is obtained. During the tests of the solid shoes, a shoe would often be observed to be warped in such a manner that it touched the wheel only at each end while at the center of the shoe the two surfaces were 1/32 in. apart, although the full braking power was applied to the shoe to force it against the wheel. Under such conditions the temperature of the bearing area would rise until the red heat had penetrated the shoe fully 1/8 in. In such cases the bearing area would not shift to a cooler part of the shoe until sufficient metal had been worn off to offset the effect of the warping. The uneven heating effect caused by the concentration of the bearing area at the two ends of the shoe would in turn cause the shoe to warp so that the ends of the shoe would be drawn away from the wheel and the bearing area again held for a comparatively long time at one spot at the center of the shoe. Such tests invariably resulted in longer stops or lower mean coefficient of friction than was the case with the same type of shoe slotted.

The resulting higher average temperature of the working metal due to the action of warping also resulted in a greater rate of wear. All the data of shoe wear show that shoes of the same type and hardness had a high rate of wear per unit of energy absorbed when a low coefficient of friction was developed and likewise a lower rate of wear when a higher coefficient of friction was developed. In other words when the coefficient of friction is high, the average temperature of the working metal must be comparatively low and therefore the metal torn from the surface of the shoe works more effectively because it is at a lower temperature and consequently less metal is required to do a given amount of work.

C The shifting of the bearing area will tend to be more rapid if the size provides more available area for shoe bearing. The average working temperature will also be reduced because a shoe of large area, such as a flange shoe provides better facilities for radiating and conducting heat away from the working surfaces. This is borne out by the better performance of the flange shoes in comparison with the plain shoes, both solid and slotted.

The results of both road and machine tests on brake shoes have shown that the coefficient of friction under any condition of braking power is dependent upon the initial speed, and the coefficient of friction tends to decrease as the speed is increased. This condition can be expected from the fact that the total energy to be absorbed during a given stop is always proportional to the square of the initial speed. The effect of the higher speeds is to increase the rate at which the temperature of the working metal changes, and although

the actual bearing areas will shift more rapidly, the greater tendency to a general heating of the shoe reduces its ability to conduct or radiate heat from the face of the shoe. For these reasons the average temperature of the working metal is consistently higher at higher speeds, and the coefficient of friction correspondingly lower.

VII. CONCLUSIONS

AIR BRAKE

The characteristics of the mechanism available for controlling the air pressure in the brake cylinders determine in a large measure the length of the emergency stop, the reliability and flexibility of the brake operation in service applications and in general the safety, convenience, comfort and economy of train control.

The state of the art has been advanced to a marked degree in all of these directions by the developments of recent years as exemplified in the apparatus used in these tests. What has been accomplished can be broadly summarized as follows:

(*A*) Desired results are insured with greater certainty.

(*B*) Undesired results are guarded against more effectively.

(*C*) An adequate capacity for present and future requirements is provided.

In service applications with the improved (UC) equipment a greater flexibility of operation is provided. That is, the braking power per pound of brake pipe reduction is lower, thus giving the engineer a greater time in which to use judgment when manipulating the brakes. At the same time, however, the maximum braking power obtainable in a full service application is higher.

A more sensitive and prompt release of the brakes is insured, tending to improve the releasing action of all brakes in the same train of mixed old and new equipments.

The action of the old and the new equipments mixed in the same train is harmonious and free from rough slack action or shocks both in service and emergency operation.

The UC equipment is adaptable to any weight of car and may be installed to furnish any desired nominal per cent of braking power.

With the new equipment operating electrically or pneumatically, there is always available a quick acting and fully effective emergency brake. This is not the case with the old equipment, in which the relation of the service and emergency functions is such that a quick action application could not be obtained after a service application of any consequence. The following average results indicate the degree to which this difference has an effect on the length of stop. Considering the ordinary full service stop from 60 miles per hour with both brakes (say 2000 or 2200 ft.) as 100 per cent, the attempt to make an emergency application with the old equipment does not produce any shorter stop than if only a full service application were made. With the improved apparatus operating pneumatically, an emergency application following a partial service application will shorten the stop about 14 per cent and after a full service application about 10 per cent.

With the electro-pneumatic brake these figures are respectively 23 and 15 per cent.

An electrically controlled brake application has been recognized as ideal ever since the report to this effect presented by the Master Car Builders' Committee in charge of the famous Burlington Freight Brake Trials in 1886 and 1887, for the reason that thereby the time element in starting the application of the brakes on various cars in the train is eliminated, a correspondingly shorter stop made, and the possibility of shocks at any speeds removed. With the new brake apparatus the effectiveness of the pneumatic emergency application is so considerably increased that the saving in time due to electric control has proportionately less influence on the length of stop, but its effect in eliminating serial action and consequently the possibility of shocks due to brake application is of correspondingly greater importance.

The graduated release feature of the improved brake apparatus permits stops to be made shorter, smoother and with a greater economy in time and compressed air consumption.

The new apparatus can be applied to give only the equivalent of the old standard apparatus if desired but in such a form the complete new apparatus can then be built up by the addition of unit portions to the simplest form of the mechanism.

The electro-pneumatic brake acts as an automatic telltale in cases of malicious or accidental closing of an angle cock after the train is charged by permitting all the brakes to apply, it being thereafter impossible to release the brakes behind the closed cock until the cock is opened.

The PM equipment will start to apply on a brake pipe reduction of 2 lb. A 4-lb. brake pipe reduction is required to start an application with the UC equipment, thereby preventing undue sensitiveness to application on slight, unavoidable fluctuations in brake pipe pressure. As a bona fide service reduction of more than 4 lb. continues, the rate of attainment of braking power is the same as if no stability feature had existed.

The attainment of full service braking power on the entire train with the UC equipment operating pneumatically was 16 seconds, 33 per cent longer than with the PM equipment because of the smaller size reservoirs used for greater flexibility.

Full service braking power was obtained in nine seconds with the electro-pneumatic brake but without sacrificing desirable flexibility because of the increased

sensitiveness of control when operating the brakes electrically.

The time of transmission of serial quick action through the brake pipe is practically the same with UC and PM equipments.

The time to obtain full emergency braking power with the PM equipment on the entire train was 8 seconds; with the UC equipment operating pneumatically 3.5 seconds or 56 per cent shorter; with the electro-pneumatic equipment 2.25 seconds or 72 per cent shorter.

The gain in emergency stopping power of the electro-pneumatic equipment over the PM equipment results from: (*a*) the shorter time occupied in applying the brakes; (*b*) a higher brake cylinder pressure obtained; (*c*) the holding of the pressure as obtained, without blow-down, as with the high-speed reducing valve of the PM equipment.

Designating the time of equivalent instantaneous application of retarding force by t, and the braking power, corresponding to the brake cylinder pressure obtained, by P, the values of t for emergency applications with the PM equipment 12 car train range from 2 to 2.5 seconds, for the UC pneumatic from 2 to 2.5 and for the electro-pneumatic from 0.7 to .85 seconds.

The observed average value for P, with the PM equipment (for a nominal 113 per cent braking power on the cars) ranges from 95 per cent to 100 per cent. With the UC pneumatic equipment and electro-pneumatic equipment, nominal emergency braking powers of 90, 125, 150 and 180 per cent were used, which, due to locomotive effect, become for the complete train 90, 117, 137 and 160 per cent respectively.

With the electro-pneumatic brake a uniform increase in per cent of braking power results in a substantially uniform decrease in length of train stop. An increase of 5 per cent in braking power reduces the length of stop about 2 per cent within the range of braking powers tested.

The available rail adhesion varies through wide limits, e.g., from 15 per cent in the case of a frosty rail early in the morning to 30 per cent for a clean, dry rail at mid-day.

The amount of wheel sliding depends more on the rail and weather conditions than on the per cent braking power. Some sliding was experienced with braking powers as low as 90 and 113 per cent where rail conditions were unfavorable, but 180 per cent braking power did not cause wheel sliding with good rail conditions.

The effect of excessive wheel sliding was to make the length of the stop about 12 per cent greater than similar stops without wheel sliding.

A braking power low enough to eliminate the possibility of wheel sliding on a bad rail results in longer stops than could be considered satisfactory for general service. Since good rail conditions prevail a large part of the time, the preferable emergency braking power is that which, considering the installation conditions, will stop trains at all times in as short a distance as can be accomplished without trouble from wheel sliding in such cases as are to be anticipated when emergency stops have to be made under unfavorable rail conditions. Advantage might be taken of this fact to use a higher braking power in summer than could be used in the winter with the same degree of freedom from objectionable wheel sliding.

The relation between the opposing forces on the wheel when sliding is about to commence can be expressed as follows:—

$$F = H_m$$
$$Pwef_s = wf_r$$
$$P = \frac{f_r}{ef_s}$$

in which

F = tangential retarding force of shoe on wheel
H_m = maximum force of friction between wheel and rail (at instant of slipping)
P = nominal per cent braking power
w = weight on wheel, lb.
e = transmission efficiency of brake rigging
f_s = coefficient of brake shoe friction
f_r = coefficient of rail friction

This establishes the value of the per cent braking power which must exist at each instant of the stop if the vehicle is to be brought to rest in the *shortest possible* distance.

But it has already been shown that if other conditions are constant a change in braking power will produce a corresponding change in the mean coefficient of brake shoe friction, the relation derived for the conditions under consideration being

$$f_s = \frac{0.12}{P^{0.419}}$$

Substituting this value of f_s in the above equation for P, we have

$$P = \frac{f_r P^{0.419}}{0.12e}$$

$$P^{0.581} = \frac{f_r}{0.12e} = \frac{8.33 f_r}{e}$$

For a 60 m.p.h. stop on a good rail f_r can safely be taken at 25 per cent and e for four-wheel trucks can be made at least 85 per cent.

Then

$$P^{0.581} = \frac{8.33 \times 0.25}{0.85}$$

for which

$$P = 470 \text{ per cent}$$

This, of course, is beyond the range of the tests which furnished the data from which the relation $f_s = \frac{0.12}{P^{0.419}}$ was derived, and consequently the result signifies nothing more than that, under the conditions assumed above, an extremely high nominal braking power would be

necessary in order to cause the wheels to slide. As a matter of fact, tests at about 400 per cent nominal braking power are on record in which practically no sliding occurred.

On the other hand, considering the variation in coefficient of brake shoe friction and rail friction that must be counted upon in service, it is advisable to limit the tangential retarding force, F, to a value less than H_m by an amount I which is proportional to the degree of protection against wheel sliding considered necessary under the ordinary condition of rail likely to be encountered, including also due allowance for the effect of surges in the train, non-uniformity of braking conditions on different vehicles, reasonable protection against excessive wheel sliding under bad rail conditions and all other causes tending to cause the wheels to slide.

The equation of condition is then

$$F = H_m - I$$

The value of I is entirely arbitrary, due to the wide range of variation of its elementary factors, according to locality, time of year, state of weather, character of train and equipment and so on.

For the purpose of illustrating the extreme opposite to that given above, suppose that I be taken as $0.25\ H_m$. Then

$$F = 0.75H_m$$

$$P = \frac{0.75f_r}{cf_s}$$

Again assuming the relation $f_s = \frac{0.12}{P^{0.419}}$, as above, we have

$$P^{0.581} = \frac{6.25f_r}{e}$$

Considering $e = 85$ per cent as before and taking $f_r = 12$ per cent, which was the lowest observed rail friction, under as poor rail conditions as could well be imagined, we have

$$P^{0.581} = \frac{6.25 \times 0.12}{0.85}$$

from which $P = 81$ per cent.

As a matter of fact some wheel sliding was obtained during the tests with 85 per cent to 90 per cent braking power when very bad rail conditions prevailed. For practical purposes a conservative value for f_r would be 15 per cent. If now a nominal braking power of 150 per cent is used the corresponding margin I against wheel sliding can be calculated from the formula $I = kH_m$ and $F = H_m - kH_m = (1 - k)\ H_m = CH_m$; from which $C = \frac{F}{H_m} = \frac{Pef_s}{f_r} = \frac{P^{0.581}e}{8.33f_r}$

Substituting the values $P = 1.5$, $e = 0.85$ and $f_r = 0.15$, we have

$$C = \frac{(1.5)^{0.581} \times 0.85}{8.33 \times 0.15}$$

from which $C = 0.86$

therefore $F = 0.86H_m$

and $k = 1 - C = 0.14$

That is to say, *under the assumed conditions,* when using a braking power of 150 per cent with as bad a rail condition as is represented by the extremely low value $f_r = 15$ per cent, the mean retarding force developed by the brake shoe is still 14 per cent less than the adhesion of the wheel to the rail.

The amount of wheel flattening when sliding occurs depends upon the weight upon the wheels, the materials in the wheels and rails, and the condition of the rail surface. The rail surface may be such that relatively long slides will produce but small flat spots, or, conversely, short slides may produce flat spots of a size requiring prompt attention.

When the UC equipment is used on the cars an arrangement giving a high emergency braking power on the locomotive, with a blow-down feature, has advantages as follows:

(*a*) Shocks between locomotive and cars practically eliminated

(*b*) Shorter stops

(*c*) No more wheel sliding than to be expected with the present installation of ET equipment.

BRAKE RIGGING

An efficient design of brake rigging must be produced before the advantages of improved air brakes or brake shoes can be fully utilized.

The use of the clasp type of brake rigging eliminates unbalanced braking forces on the wheels and so avoids the undesirable troublesome journal and truck reactions that come from the use of heavy braking pressures on but one side of the wheel. This has an important effect not only on freedom from journal troubles but also in enabling the wheel to follow freely vertical inequalities of the track.

The clasp brake also improves the brake shoe condition materially, both as to wear and variability of performance.

Although the clasp brake rigging will produce better stops than a single shoe brake rigging equally well designed (other conditions being equal), its advantage in this direction is of less importance than in the improved truck, journal and shoe conditions mentioned above.

The tests indicated that at least 85 per cent transmission efficiency could be obtained with either single shoe or clasp brake rigging.

The following features were observed to be of importance if maximum overall brake rigging efficiency is to be secured:

(*a*) Protection against accidents that may result from parts of rigging dropping on the track.

(*b*) Maximum efficiency of brake rigging at all times to insure the desired stopping with a minimum per cent of braking power.

(*c*) Uniform distribution of brake force, in relation to weight braked, on all wheels.

(*d*) With a given nominal per cent braking power, the actual braking power to remain constant throughout the life of the brake shoes and wheels.

(*e*) Piston travel to be as near constant as practicable under all conditions of cylinder pressure.

(*f*) Minimum expense of maintenance and running repairs of brake rigging between the shopping of cars.

BRAKE SHOES

The brake shoe bearing was the most difficult factor to control and at the same time the most potent in producing variations in brake performance.

The tests established the possibility of a variation of 15 to 20 per cent in length of stops from 60 m.p.h. with all factors except brake shoe condition remaining substantially constant. Continued stopping with moderate braking pressures produced a constantly improving brake shoe condition and shorter stops. This is evidence that with reasonable attention to brake shoe maintenance, the condition of the shoes on cars in ordinary road service is likely to be more favorable to making short emergency stops than during a series of tests in which the brake shoes are worked severely.

The difference in the efficiency of the clasp and single shoe rigging may offset the gain which might be expected from difference in coefficient of friction and vice versa. Consequently as neither of these factors could be observed uninfluenced by the other, a satisfactory comparison of the mean coefficient of friction under different rigging conditions or of different types of rigging or air brake apparatus under variable shoe conditions in road tests, is impossible.

High braking powers from high initial speeds result in a great heating of the working surface of the shoe and a rapid abrasion. This effect is most marked under severe braking conditions such as obtained when heavy cars equipped with one brake shoe per wheel are stopped.

Shoes of the same type and hardness had a high rate of wear per unit of energy absorbed when a low coefficient of friction was developed and, conversely, a lower rate of wear when a higher coefficient of friction was developed.

Both the road and the laboratory tests confirmed previous tests and conclusions from analysis that the temperature of the working metal is the determining influence in coefficient of brake shoe friction. The other factors that may be involved become effective chiefly as they affect the change of temperature of the working metal.

The general performance of the shoes as observed during the road tests formed the basis of the program established for laboratory tests, which resulted in the following deductions:

(*a*) The generation of the retarding forces and consequent absorption of the energy of the moving train is dependent upon but a very small quantity of brake shoe metal.

(*b*) The actual bearing area rather than the total face area of the shoe is the important factor in brake shoe performance.

(*c*) The magnitude of the bearing area changes throughout the stop and is greatest near the end of the stop.

(*d*) The bearing area shifts continuously from one portion of the surface to another during the stop.

(*e*) The principal factor in producing high friction for any given braking condition is the frequent shifting of the bearing area from the heated to the cooler spots over the face of the shoe.

(*f*) Slotted shoes or shoes that are cracked are more flexible than solid shoes and the bearing area shifts more readily than in the case of solid shoes.

(*g*) With shoes of the same type and approximately the same hardness, the wear per unit of work done is less with the slotted shoe than with the solid shoe. The stops with slotted shoes were always shorter and the mean coefficient of friction higher than with solid shoes.

(*h*) The shifting of the bearing area will tend to be more rapid if the size provides more available area for shoe bearing.

(*i*) The greater the pressure per square inch of bearing area, the lower will be the mean coefficient of friction.

(*j*) Flanged shoes provide more available area for bearing than unflanged shoes.

(*k*) The use of two shoes instead of one per wheel will result in a higher coefficient of friction and less wear per unit of work done.

(*l*) A comparison of the values of mean coefficient of friction for standard and for clasp brake conditions indicates a decided advantage for the clasp brake throughout the entire range of braking powers. The gain in favor of the clasp brake with slotted shoes amounts to about 40 per cent, at a braking power of 180 per cent, and 100 per cent, at a braking power of 40 per cent, an average gain for the whole range of braking powers of about 70 per cent.

(*m*) From a brake shoe standpoint the advantage of using two shoes instead of one shoe per wheel may be summed up as follows:—

First. The clasp brake shoe is associated with but one-half the wheel load and consequently has but one-half as much energy to absorb.

Second. The clasp brake shoe is working at only one-half the shoe pressure at which the standard shoe must work under the same braking power.

Third. The *available* working area for the same amount of energy to be absorbed is double.

A possible source of disadvantage when using two shoes per wheel is that a warped or poorly bearing shoe is subjected to less pressure tending to force it into a good contact with the wheel. For this reason, though the available shoe area is doubled when using clasp brakes, the actual *amount of working metal* throughout the stop may be less than with a single shoe, which is less capable of resisting the tendency of the heavier pressure to cause a better fit of shoe to wheel.

This, and an especially good shoe condition due to previous moderate pressure tests in each case, is an explanation why three of the 60 m.p.h. 150 per cent braking-power electro-pneumatic stops with the single shoe train were shorter by 50 ft. than the best stops of either of the first or second clasp brake trains.

On the other hand the disadvantage and greater variability of the single shoe brake is evidenced in the fact that under the same conditions as cited above two stops with this train were longer than the longest stops without material wheel sliding made with either of the two clasp brake trains.

With plain solid shoes the durability will be increased 41.1 per cent under clasp brake conditions as compared with that under single shoe conditions.

With plain slotted shoes the durability will be increased 33.5 per cent under clasp brake conditions as compared with that under single shoe conditions.

The superior durability of the plain slotted shoe as compared with the plain solid amounts to 11.7 per cent under single shoe brake conditions and 5.9 per cent under clasp brake conditions.

The wear of the flanged solid shoes per unit of work done is 19 per cent less than for plain solid shoes, and for flanged slotted 26 per cent less than for plain slotted shoes, or 30 per cent less than the plain solid shoes.

The wear of plain slotted shoes per unit of work done is 5.4 per cent less than the wear of plain solid shoes, and the wear of the flanged slotted is 13.2 per cent less than the wear of flanged solid shoes.

For the same amount of work done flanged solid cost 16 per cent less than plain solid shoes, and flanged slotted cost 23 per cent less than plain slotted, or 27 per cent less than plain solid shoes.

Approximately 135 per cent more stops will be required to wear out the flanged solid than will be required to wear out the plain solid shoe; 158 per cent more stops to wear out the flanged slotted than the plain slotted shoe, and 171 per cent more stops to wear out the flanged slotted than the plain solid shoe.

For any given braking condition with cast-iron brake shoes the indications are that the best relation will exist between shoe wear and the mean coefficient of friction when the Brinell hardness of the cast iron is about 190.

Machine and road tests show a difference in stopping distance for the same type of shoe under the same braking conditions.

The effect of the difference in wheel surface conditions is one of the leading factors which go to make up the difference between machine and road tests. The difference in braking performance can be established and the factor expressing this difference be applied to laboratory results to predict the performance of a car or train.

LENGTH OF STOP

The stops and observed performance of the air brake, brake rigging and brake shoe are in agreement with the relation generally assumed to exist between the speed and other variables mentioned and resultant length of stop. This relation for straight, level track and neglecting air and internal friction on the one hand and the rotative energy of the wheels and axles on the other hand, is:

$$S_t = 1.467Vt + \frac{V^2}{30Pef}$$

in which the terms have the following significance and range of values according to conditions

S_t = length of stop to be expected in ft.

V = initial speed of train in m.p.h.

t = time at the beginning of the stop during which the brakes are to be considered as having no effect, to allow for the time element in the application of the brakes

	Kind of Air Brake Equipment	
	PM	UC Electro-Pneumatic
For a 12-car train		
t ranges from	2.0	0.70
t ranges to	2.5	0.85

P = nominal per cent braking power corresponding to the average cylinder pressure existing for that portion of the stop after the brake is considered fully applied,

With a single car or several similar cars, stopping without the locomotive attached, the value of P can be obtained from an average of all brake cylinder indicator cards or taken from one typical brake cylinder card, provided all cylinder pressures and foundation brake installations are substantially alike.

Where car weights differ or where the locomotive is attached, the average per cent braking power (P) for the train (total weight W) may be calculated from the formula

$$P_t = \frac{\Sigma P_c W_c + P_n W_n + P_e W_e}{W_t}$$

in which

P_c = nominal per cent braking power corresponding to average cylinder pressure of cars as noted above

W_c = weight of car in lb.

W_n = actual total weight of tender in lb.

P_n = nominal per cent braking power corresponding to tender cylinder pressure and to W_n

W_e = weight of engine in lb.

P_e = nominal per cent braking power corresponding to engine cylinder pressure (aggregate for driver, truck and trailer wheels according to distribution of weights and nominal braking power)

$e \times f$ = product of efficiency of brake rigging and mean coefficient of brake shoe friction, in which

e varies with the type and installation of brake rigging and with the per cent braking power, though the latter effect can be but slight throughout the range of ordinary emergency braking powers

f varies with the kind and initial condition of the brake shoe bearing surface, the initial speed and the various influences affecting the conditions of the bearing surface during the stop.

As no satisfactory separate determination of e and f was found possible the combined factor $e \times f$ is given in the following table, the values being representative of the best performance that might reasonably be expected under conditions comparable with those of this test.

TABLE 3 VALUES OF $e \times f$.

Kind of Brake Rigging		Clasp Brake		Single Shoe[1]	
Type of Brake Shoe					
Speed m.p.h.	Braking Power	Plain	Flanged	Plain	Flanged
	125	0.141	0.169	0.108	0.112
30.....	150	0.129	0.154	0.099	0.103
	180	0.118	0.141	0.090	0.094
	125	0.103	0.122	0.074	0.090
60.....	150	0.094	0.112	0.068	0.082
	180	0.086	0.102	0.062	0.075
	125	0.092	0.109	0.070	0.071
80.....	150	0.084	0.100	0.064	0.068
	180	0.077	0.092	0.059	0.062

[1] Value of data uncertain due to non-uniform brake shoe conditions.

DISCUSSION

J. P. Kelley[1]: To the author's statement that the sliding of wheels under brake applications is due largely to rail adhesion, I am inclined to add that the percentage of braking power employed is not of itself the cause of sliding. With the trucks and gears that are familiar to us, the braking forces are not evenly distributed over all the wheels and it is possible for the weight to be momentarily shifted from one or more of the wheels during the progress of a stop with brakes applied.

From a study of clasp brake design and foundation brake gear, as well as from experience, I should say that the clasp brake is the only suitable one to use on present day passenger car equipment. While it will not do away with the shock, it will go a long way towards keeping the wheels in their normal position with relation to the other parts of the truck, and to the rails, and so aid in making available whatever spring action is there to keep the wheels where they belong and to keep the rail adhesion uniform and constant. By this means the pressure on the wheels is balanced; also the number of hot boxes, is reduced.

We have had considerable experience with clasp brakes on quite a number of our cars during this present winter, and with a few of them the previous winter, and find that as the shoe is higher above the rail in an emergency application than with the common type of gear, there is less chance for the accumulation of snow and ice on the shoe to drip off upon the rails when the shoe gets hot, and so reduces the friction.

To show that uneven braking power rather than the per cent of braking power considered in itself is productive of wheel sliding, a recent case may be cited of a train of nine cars, where the highest braking power would probably run 115 per cent, the lowest about 65 per cent, and the average through the train about 85 per cent. Through an accident the brake pipe was broken off on the fourth car from the rear. Every car ahead of the rear car came to a stop without injury to the wheels. They were the ones on which the braking power was very low. The rear car had normal braking power, and all but two pairs of its wheels were slid flat. This could be explained on no other principle than that when the brake application was initiated at the fourth car, and propagated in opposite directions, there was not only the braking power acting on the wheels, but also the effect of shock set up because of the difference in time and the difference in the power with which the brakes went on, which "jumped" the wheels along and caused them to skid to such extent as to break or very materially reduce their rail adhesion.

With reference to emergency application, if a brake will operate instantaneously and simultaneously throughout the train, with almost any degree of flexibility, emergency stops, as such, can be very materially reduced. A brake that will operate instantaneously will bring a train to a stop with a service application, within a distance for which another brake equally powerful but much slower in action, would require an emergency application.

H. H. Vaughan. A point which is brought out in these tests, is the trouble with wheels sliding. About a year ago we went into the question of flanged shoes to reduce the brake shoe pressures, and found an extraordinary increase in wheels slid, especially in cold weather. We then tried unflanged shoes, without any other change, and the sliding reduced. I have no reason to give for this, but it is a point worth bringing up, and the sliding of wheels, while shown in rather a curious way in this paper, is really a very serious and expensive thing, especially in cold weather, in which I am pleased to say I have had a large and most unlimited experience. Wheels sliding with us is undoubtedly a prominent cause of shelled out tires. When it is known that we rarely run a car over 6000 miles in winter without having a wheel with shelled out tires, it can be imagined how serious it is.

Regarding the paper in general, one is impressed by the marvelous ingenuity of the whole apparatus. It is a wonderful piece of mechanical invention, and one cannot help wondering where we are going to get to in this air brake matter. Probably there was never a more ingenious machine than the plain triple valve invented by Mr. West-

[1] Cons. Air-Brake Engr. of the N. Y. C. & H. R. R. R. Co.

inghouse, which made possible the use of automatic air brakes on passenger equipment. In 1887, when the Burlington tests were being conducted, Mr. Westinghouse supplemented his plain triple valve by the quick-action triple, which again was a peculiarly brilliant invention and the fame of Mr. Westinghouse as an inventor will probably rest more on these two inventions, which are the foundation of our modern air brake system, than on all the other things he has done.

The quick-action triple valve behaved very well during the early years of its life, but about the time when it was twenty years of age, like many of us, it began to branch out, and there was attached to the quick service application the retarded release and then a reservoir or two was annexed to the air brake system, giving the graduated release and higher pressure in emergency. There was the LN, and then the PC, and now we are to have the UC, the greatest development of all, which will work either pneumatically or electrically. If the electrical part breaks down, the pneumatic part comes on and works, and the whole thing is wonderful, all the way down from the plain triple, as a monument of inventive genius.

At the same time—I do not wish to raise a discordant voice—are we wise, are the railroad companies wise, is the Westinghouse Company wise, in this development in which the apparatus is continually being revised to interchange with all the other developments that have gone before it? Would it not be possible to design the electro-pneumatic brake without this complication? It is a wonderful thing, but should it be put on every passenger car without very serious consideration?

I consider that the Westinghouse Company, supplementing this paper, should tell us what is necessary in the straight electro-pneumatic brake in which the train pipe carries the air and the electricity does the application, and I venture to say, without knowing exactly what would be the answer, that it would be an exceedingly simple and highly efficient apparatus. I cannot help thinking that an electro-pneumatic brake, even with the safety automatic feature on the air pipe, so that a fracture of an air pipe would cause the application of the brakes, would not be anything like the complicated apparatus we are getting today in order to make these things interchangeable and universal.

W. B. Turner[1] said in response to Mr. Vaughan's remarks on the complexity of air-brake apparatus that the electro-pneumatic brake has been used for traction service for the past seven years under several thousands of cars; and has been used on the subway system in New York for several years, which is the most severe service in the world, where it has given good results. The electro-pneumatic apparatus can be applied to practically any equipment that has been built up to the present time and will function in a satisfactory manner, but it will not do what the improved air brake equipment (type UC) described in the paper will accomplish. To attain the results which have been detailed it is essential to have this equipment or its equivalent. While he would welcome any apparatus that was less complex, this would be impossible if it is desired to do the things which are necessary to control the trains of to-day in the best manner possible. If Mr. Vaughan had his double brake equipment and the supplemental devices for cutting-out the brakes etc., he would find that the equipment would be vastly more complex than that shown in the paper—it would be so complex that he would be afraid of it himself.

[1] Chief Engineer of the Westinghouse Air Brake Company.

Mr. Turner then presented the following written discussion:

The present day conditions in railroading that affect the air brake problem are:

a Higher Speed, because the energy to be dissipated increases as the square of the speed, which means, other things being equal, that the length of the stop will also increase as the square of the speed.

b Heavier Vehicles, because doubling the weight doubles the energy to be dissipated. The combined effect of doubling the speed and doubling the weight is to increase the energy to be dissipated eight times.

c Longer and Heavier Trains. These increase the difficulty of control and greatly magnify reactions due to "slack" between cars.

d Greater Frequency of Trains. This increases the probability of accident and therefor the necessity for more efficient control.

e Parallel Tracks. This also increases the danger, as an accident on one track may cause one on any of the other tracks.

Any one of these changes in conditions makes imperative a compensating change in effectiveness in the means for controlling trains, but when they are all taken collectively, as they must be, the seriousness of the problem is even more apparent and, to one who knows the potential, alarming. But this is not all, for the very conditions that thus called for more effective brake appliances also decreased the efficiency or effectiveness of those existing by almost one-half. The predicament, therefore, is one requiring prompt attention and the creation of means not heretofore in existence.

The reasons why the above-mentioned conditions decrease the effectiveness of the brake control are:

Increased speed (work) causes a decrease in the mean coefficient of friction; and as the stopping distance is proportional to the coefficient of friction, the stop becomes longer.

Heavier vehicles also increase the work required of the brake shoe in a given time, and this further reduces the coefficient of friction. Also, as a result of the greater forces exerted, there are distortions and consequent losses in foundation brake gear efficiency. Again, much larger brake cylinders are necessary and this increases the time required to get full braking power, these three losses contributing, as is apparent, to a further material increase in stopping distance.

Longer trains lead to another decrease in effectiveness by adding to the time required to get the brakes on, while the combination of greater weight and length increases the volume of air required with consequent difficulty of recharging quickly. There is also the difficulty of controlling trains smoothly because of the bunching and stretching of such a number of heavier cars and the time-lapse between the brakes applying on the front and rear end of the train.

Greater frequency of trains and parallel tracks make improvement necessary by requiring much more frequent brake applications, thus exhausting the air supply, and also by making it imperative to be able to obtain maximum emergency

braking force at any time. Collectively, it will be seen that these changes mean much, nor must it be overlooked that one serious effect is the increased risk we must take with the human element.

To illustrate the foregoing by example, in 1890 with a train weight of 280 tons and a speed of 60 miles per hour, the energy to be dissipated was about 33,000 ft-tons and the stopping distance was 1000 ft.

In 1913, with a train-weight of 920 tons and a speed of 60 miles per hour, the energy to be dissipated is 111,000 ft-tons, or almost four times greater than that of the first mentioned train. With an old-style brake the collision energy as this train passed the point where the first mentioned train stopped would still be 48,000 ft-tons, or one and one-half times what the first mentioned train had before the brake was applied and there would still be 760 ft. to run.

This modern train, but now equipped with the new brake apparatus, running at a speed of 60 miles per hour, can be stopped in 860 ft., at which point, with the old brake equipment, it would still be running at 43 miles per hour and with a collision energy of 57,000 ft-tons or still about twice that contained in the train of 1890 at the beginning of the stop.

When the full force and meaning of the increased stopping distance is realized, in connection with the possibility of accidents arising from the greater frequency of trains and number of parallel tracks, it will be seen that not only are improvements in brake equipment really necessary, but also that the best that can be designed is none too good.

F. W. Sargent. In conducting machine tests of brake shoes it is our practice to make a number of runs to get the shoes down to a good bearing and then make a number of records and average them. The average figures derived from repeated tests upon different shoes should be comparable with the results that might be obtained from the brake-shoe equipment of a train. The great variation in the train records as presented in the paper must be due, I think, to some neglect in the foundation brake rigging, rather than to a bad condition of all the brake shoes at one time.

The agreement between the results of the brake shoe testing machine and the road tests is extremely gratifying. When we first began testing brake shoes on the machine we encountered very large variations in the results, particularly with the heavy solid new shoes. But as the shoes wore down, and especially when they cracked and fitted the wheels better, the results became more uniform. When the shoes became thin and near the point where they ought to be removed, it developed that under the extreme pressures common to modern high-grade equipment, with the single brake, we were reaching the danger point and there was a possibility of the shoe melting. Such a condition would be realized on the road if the brakes were applied on a grade and then an emergency stop followed while the shoes were still warm. Under such a condition the shoes might be heated to a point where they would lose their grip on the wheels to a large extent, even if not melted away, and cause the brake to fail. It seems to me that the only thing which will prevent this is the adoption of the clasp brake. Besides saving the brake shoe from possible destruction, the test records indicate that with the two-shoe combination there is an actual gain in the retardation.

R. R. Potter.[1] It may be of interest to speak of some tests made recently on the New York, Westchester & Boston Railway, to determine the efficiency of the clasp brake. The cars, which are operated electrically, weigh 60 tons, and are run as high as 60 miles an hour. In making the test, a motor truck without motors, which has clasp brakes, was put under the trailer end of the car, which normally has a simple truck. At 35 miles per hour the deceleration under an emergency application of the brake was found to be 4 miles per hour per second with the clasp brake; with the simple brake, it was 3.3 miles per hour per second. At 50 miles per hour, the deceleration was 3.65 miles per hour per second with the clasp brake, and with the standard brake, 3 miles per hour per second. The length of stop with the clasp brake, at 50 miles per hour, was 585 ft., and with the simple or standard brake 690 ft. These were the average lengths of stop for about 40 stops. Invariably the stops were shorter when the clasp brake was used. Stops were made at various speeds, principally at 35 and 50 miles per hour.

S. G. Thomson.[2] I am particularly interested in the business end of this new brake, the part which involves its practical application. After listening to the discussion, the important thing to me seems to be the development of the foundation brake. Have we tried out the foundation brake far enough? Have we gone far enough with the clasp brake in increasing the friction applied on the wheels and are we not going too far for the present in this development of the electric control? I am inclined to agree with Mr. Vaughan in respect to the matter of complications.

We have had considerable experience with the clasp brake on our road for a number of years, running it on 100 or more cars, with four and six-wheel trucks, high-speed service. All are giving excellent results, so that it seems to me more important at the present time to extend the use of the clasp brake than to hasten the electric development. Let the electric control be a matter of gradual unfolding.

How much benefit would this electric control as presented here to-night be to us? I figure that the principal gain would be in the little time saved by applying a considerably greater pressure in the brake cylinder; also that there would be a considerable advantage in making an emergency application after the service application has been made. Is that really of sufficiently great importance in actual train service to warrant all this complication and expense?

T. L. Burton.[3] Both Mr. Sargent and Mr. Vaughan have spoken of the wheel sliding effect of the flanged brake shoe. I have had considerable experience with this and, as the former stated, have found the trouble with the flanged shoe to be due largely to the brake gear, especially the spacing of the heads on the brake beams and the deflection of the beams under various loads.

There has been a question in the minds of some as to the relative stopping effect of the clasp and single-shoe types of brake, all conditions, excepting the performance of the gear and the shoe, being the same. For any set of conditions such as stated in Table 10, the length of the stop should be inversely proportional to the value of $e \times f_s$; consequently, so far as the brake shoe and rigging are concerned, Table 3

[1] Supt. of Equipment, N. Y. W. & B. Ry.
[2] Supt M. P. and Rolling Equip., Phila. & Reading R. R.
[3] Westinghouse Air Brake Co., 165 Broadway, New York.

affords a precise means of comparing the length of stops obtained with the various types of brake gear and brake shoes used in the test with which the report deals.

I have prepared some supplementary tables, reducing Mr. Dudley's comparison to a percentage basis. Accepting the values of e and f, as shown in Table 3 for clasp brakes and flanged shoes as 100 per cent, the relative length of stops for clasp and single shoe brakes should be as follows:

RELATIVE LENGTH OF STOP

Speed in M. P. H.	Per Cent Braking Power	Clasp Brakes: Plain Shoes	Clasp Brakes: Flanged Shoes	Single Shoe Brake: Plain Shoes	Single Shoe Brake: Flanged Shoes
30	125	$\frac{0.169}{0.141}=1.199$	$\frac{0.169}{0.169}=1.000$	$\frac{0.169}{0.108}=1.565$	$\frac{0.169}{0.112}=1.509$
30	150	$\frac{0.154}{0.129}=1.194$	$\frac{0.154}{0.154}=1.000$	$\frac{0.154}{0.099}=1.556$	$\frac{0.154}{0.103}=1.495$
30	180	$\frac{0.141}{0.118}=1.195$	$\frac{0.141}{0.141}=1.000$	$\frac{0.141}{0.090}=1.567$	$\frac{0.141}{0.094}=1.500$
60	125	$\frac{0.122}{0.103}=1.184$	$\frac{0.122}{0.122}=1.000$	$\frac{0.122}{0.074}=1.648$	$\frac{0.122}{0.090}=1.356$
60	150	$\frac{0.112}{0.094}=1.191$	$\frac{0.112}{0.112}=1.000$	$\frac{0.112}{0.068}=1.647$	$\frac{0.112}{0.082}=1.366$
60	180	$\frac{0.102}{0.086}=1.186$	$\frac{0.102}{0.102}=1.000$	$\frac{0.102}{0.062}=1.645$	$\frac{0.102}{0.075}=1.360$
80	125	$\frac{0.109}{0.092}=1.185$	$\frac{0.109}{0.109}=1.000$	$\frac{0.109}{0.070}=1.557$	$\frac{0.109}{0.074}=1.473$
80	150	$\frac{0.100}{0.084}=1.190$	$\frac{0.100}{0.100}=1.000$	$\frac{0.100}{0.064}=1.563$	$\frac{0.100}{0.068}=1.471$
80	180	$\frac{0.092}{0.077}=1.195$	$\frac{0.092}{0.092}=1.000$	$\frac{0.092}{0.059}=1.559$	$\frac{0.092}{0.062}=1.484$

INCREASE IN LENGTH OF STOP WITH THE SINGLE SHOE BRAKE AS COMPARED TO THE CLASP BRAKE

Speed in M. P. H.	Per Cent Braking Power	Plain Shoes Per Cent	Flanged Shoes Per Cent
30	125	$\frac{1.565}{1.199}-1=0.305=30.5$	$\frac{1.509}{1.000}-1=0.509=50.9$
30	150	$\frac{1.556}{1.194}-1=0.304=30.4$	$\frac{1.495}{1.000}-1=0.495=49.5$
30	180	$\frac{1.567}{1.195}-1=0.311=31.1$	$\frac{1.500}{1.000}-1=0.500=50.0$
		$\frac{1.648}{1.184}-1=0.392=39.2$	$\frac{1.356}{1.000}-1=0.356=35.6$
		$\frac{1.647}{1.191}-1=0.383=38.3$	$\frac{1.366}{1.000}-1=0.366=36.6$
		$\frac{1.645}{1.186}-1=0.387=38.7$	$\frac{1.360}{1.000}-1=0.360=36.0$
		$\frac{1.557}{1.185}-1=0.314=31.4$	$\frac{1.473}{1.000}-1=0.473=47.3$
		$\frac{1.563}{1.190}-1=0.314=31.4$	$\frac{1.471}{1.000}-1=0.471=47.1$
		$\frac{1.559}{1.195}-1=0.304=30.4$	$\frac{1.484}{1.000}-1=0.484=48.4$
Average Gain in favor of Clasp Brake, Per Cent		35.5	44.6

Tabulated results show the following *average* comparative lengths of stops:

Average stop, clasp brake, plain shoes	1.191
Average stop, clasp brake, flanged shoes	1.000
Average stop, single-shoe and plain shoes	1.590
Average stop, single-shoe and flanged shoes	1.446

Length of stop with clasp brake, plain shoes is 19.1 per cent greater than stop with clasp brake, flanged shoes.

Length of stop with single shoe brake, plain shoes is 59.0 per cent greater than stop with clasp brake, flanged shoes.

Length of stop with single shoe brake, flanged shoes is 44.6 per cent greater than stop with clasp brake, flanged shoes.

Also, length of stop with single shoe brake, plain shoes is 33.5 per cent greater than stop with clasp brake, plain shoes.

Whence the *general* average length of stop with the single shoe brake is $\frac{1}{2}$ (44.6+33.5) = 39.05% greater than the general average length of stop with the clasp brake.

The relative stopping distance of the two types of brake gear, however, tells but half the story. Mr. Dudley refers to the sliding of wheels as affected by the adhesion between the wheels and the rail. The adhesion is influenced, not only by the condition of the rail, but by the shifting of the wheel loads as affected by inertia forces, and shocks and lines of action in the brake gear.

Unfortunately, we have no control over the condition of the rail, or the effect of the inertia. The use of electro-pneumatic brakes will, however, minimize the shifting of wheel weights resulting from end shocks, and a careful analysis of many brake gears in use will disclose some remarkable facts on the equalization of wheel weights and shoe pressures as influenced by the design and application of the gear.

With the assistance of Mr. H. M. P. Murphy of our organization, we have made an analysis of the brake forces of some trucks in use on a road in this territory and their effects on the equalization of weights at wheels and shoe pressures.

I will add in brief form some results of the analysis for the brake rigging of a six-wheel passenger car truck. The tabulation relates to braking forces, wheel pressures on rail, percentage of braking power, etc., for service application, with all parts standard; and for emergency application, with shoes and tires worn and journals displaced in accordance with actual conditions observed. The nominal braking power in service was 85 per cent and in emergency, 160 per cent. The total actual weight of car under the standard conditions assumed for service is 142,000 lb. Under the worn conditions assumed for emergency the total car weight is 138,000 lb.

NORMAL BRAKE SHOE PRESSURES: SERVICE

	Leading Truck	Rear Truck.
Outside wheel	9155 lb.	8825 lb.
Middle wheel	9775 lb.	9175 lb.
Inside wheel	8130 lb.	8215 lb.

Variation in normal brake shoe pressure = 1645 lb.; per cent variation = 20.2.

NORMAL BRAKE SHOE PRESSURES: EMERGENCY

	Leading Truck	Rear Truck
Outside wheel	15,785 lb.	16,090 lb.
Middle wheel	15,605 lb.	15,555 lb.
Inside wheel	10,835 lb.	9,840 lb.

Variation in normal brake shoe pressure = 6,250 lb.; per cent variation = 63.5.

ACTUAL WHEEL PRESSURES ON RAIL: SERVICE

	Leading Truck	Rear Truck
Outside wheel	13,727 lb.	11,622 lb.
Middle wheel	10,697 lb.	11,826 lb.
Inside wheel	11,076 lb.	12,052 lb.

Variation in wheel pressure on rail = 3030 lb.; per cent variation = 28.3.

ACTUAL WHEEL PRESSURES ON RAIL: EMERGENCY

	Leading Truck	Rear Truck
Outside wheel	14,735 lb.	11,956 lb.
Middle wheel	9,816 lb.	11,234 lb.
Inside wheel	10,056 lb.	11,435 lb.

Variation in wheel pressure on rail = 4,937 lb.; per cent variation = 50.3.

ACTUAL PERCENTAGE OF BRAKING POWER: SERVICE

Leading Truck

Outside wheel: $\frac{9155}{13727} \times 100 = 66.7$

Middle wheel: $\frac{9775}{10697} \times 100 = 91.4$

Inside wheel: $\frac{8130}{11076} \times 100 = 73.4$

Rear Truck

Outside wheel: $\frac{8825}{11622} \times 100 = 75.9$

Middle wheel: $\frac{9175}{11826} \times 100 = 77.6$

Inside wheel: $\frac{8215}{12052} \times 100 = 68.1$

Variation in percentage of braking power = 91.4 − 66.7 = 24.7. Per cent variation in percentage of braking power = $\frac{24.7}{66.7} \times 100 = 37.0$.

FORCE EFFICIENCY OF BRAKE APPARATUS: SERVICE

For leading truck,

$$\frac{2 \times (9155+9775+8130)}{6 \times 9052.5} \times 100 = 99.6\%$$

For rear truck,

$$\frac{2 \times (8825+9175+8215)}{6 \times 9052.5} \times 100 = 96.5\%$$

FORCE EFFICIENCY OF CAR BRAKE, EXCLUSIVE OF CYLINDER LOSSES, ETC.: SERVICE

$$\frac{54120+52430}{2 \times 54315} \times 100 = 98.1\%$$

FORCE EFFICIENCY OF CAR BRAKE, INCLUDING ALL LOSSES

$$\frac{106550}{0.85 \times 142000} \times 100 = 88.3\%$$

ACTUAL PERCENTAGE OF BRAKING POWER: EMERGENCY

Leading Truck

Outside wheel: $\frac{15785}{14753} \times 100 = 106.9+$

Middle wheel: $\frac{15605}{9816} \times 100 = 159.1+$

Inside wheel: $\frac{10835}{10056} \times 100 = 107.7$

Rear Truck

Outside wheel: $\frac{16090}{11956} \times 100 = 134.6$

Middle wheel: $\frac{15555}{11234} \times 100 = 138.5$

Inside wheel: $\frac{9840}{11435} \times 100 = 86.1$

Variation in percentage of braking power = 159.1 − 86.1 = 73.0. Per cent variation in percentage of braking power = $\frac{73.0}{86.1} \times 100 = 84.8$.

FORCE EFFICIENCY OF BRAKE APPARATUS

For leading truck,

$$2 \times \frac{(15785+15605+10835)}{6 \times 17040} \times 100 = 82.6\%$$

For rear truck,

$$2 \times \frac{(16090+15555+9840)}{6 \times 17040} \times 100 = 81.2\%$$

FORCE EFFICIENCY OF CAR BRAKE, EXCLUSIVE OF CYLINDER LOSSES, ETC.

$$\frac{84450+82970}{2 \times 102240} \times 100 = 81.9\%$$

FORCE EFFICIENCY OF CAR BRAKE, INCLUDING ALL LOSSES

$$\frac{167420}{1.60 \times 142000} \times 100 = 73.7\%$$

N. A. Campbell.[1] After the Central Railroad of New Jersey high-speed brake tests in 1903, a relatively short time ago, it was thought that the last word had been said in high-speed braking. Stops were made from 60 miles per hour in less than 1000 ft. and until the Pennsylvania Railroad tests last year they had not been equalled. The locomotives and cars, however, were about half the weight of those now in use. The problem of braking the heavier modern cars so as to make the shortest possible stop in emergency applications has been a much more difficult one than that with which we were confronted ten years ago. Few fast passenger trains at that time averaged more than six cars in length or more than 500 tons including the locomotive. Trains of from 10 to 12 cars that weigh over 1000 tons, including the locomotive, have been a source of much trouble to some roads on account of the severe shocks and wheel sliding that resulted from emergency applications.

With the pneumatic brake, the brake cylinder pressure reaches the maximum on the forward portion of the train before the brakes have been applied on the rear. The result is that the slack has time to run in, causing a shock, more or less severe, according to conditions, and exerting a force against the forward portion of the train which has a tendency to cause slid flat wheels. Some railroad men have been protesting against the rapid rise of brake cylinder pressure in emergency applications. They said that they would prefer a slower rise of pressure in the cylinders and longer stops than the trouble due to shocks and slid flat wheels. They are justified in their complaint as far as the pneumatic brake is concerned, but I believe the electro-pneumatic brake will tend to overcome the trouble.

The use of the electric control in combination with an air brake equipment of more modern design, which has port areas sufficiently large to permit the maximum cylinder pressure to be obtained in less than half the time required by the older equipments, will very materially reduce the length of emergency stops.

However, as there are very many service stops made to one in emergency, it is just as important, if not more so, to take care of the service applications. The time required to make a service reduction of brake pipe pressure increases with the increased length of the train, and as the brakes are applied on the forward portion of the train before they are on the rear, causes shocks or surges. Electric control of the brakes causes the brakes on all cars to operate simultaneously, thus eliminating the cause of these shocks by eliminating the time element existing with pneumatic operation.

With the electro-pneumatic brake, even the indifferent or unskilled engineer can handle a long train as smoothly and accurately as a single car, while without the electric control

[1] Rep., N. Y. Air Brake Co., 165 Broadway, New York.

the careful and skilled engineer cannot always make a smooth, accurate stop, no matter how hard he tries.

THE AUTHOR. Wheel sliding, to which Mr. Vaughan refers, is perhaps one of the most elusive limitations to satisfactory brake operation. As Mr. Kelly explains, the factors involved in finally determining whether wheels slide or not in any given case are so numerous, complicated and oftentimes obscure that the assignment of a definite cause or causes or the adoption of practicable preventative measures, at the same time maintaining the desired brake effectiveness, is almost entirely a matter of judgment rather than of fixed rule.

The effect of flanged brake shoes as observed by Mr. Vaughan has been a more or less common experience on many roads in this country. On the other hand, a large railroad system in the East has used flanged brake shoes of a highly efficient type as standard on all their passenger cars for years. The cars are braked from the ordinary high-speed brake standard up to as high as 180 per cent braking power in emergency, trains being made up as the cars may come. This road has not experienced any inconvenience from wheel sliding under these conditions. As pointed out by Mr. Sargent and Mr. Burton it has sometimes been found that the brake rigging and brake head construction has been responsible for trouble experienced with flanged brake shoes. The use of worn shoes on new wheels has also been a cause of trouble.

There appears to be but one circumstance which can unhesitatingly be blamed for sliding wheels, namely, *an excess of resistance to rotation over rail adhesion.* The causes contributing to diminished rail adhesion or increased resistance to rotation are many and variable.

The considerable increase in train deceleration during the last few hundred feet before the stopping point is an evidence of the characteristic action of frictional resistance at constant pressure, when the speed of relative motion of the rubbing surface is being continually reduced from a relatively high value to zero. This phenomenon was first observed and commented upon in the report of the classical Galton-Westinghouse Brake Trials on the London, Brighton & South Coast Railroad in 1878 and 1879, and was at that time attributed to the effect of speed.

All subsequent experiments have developed this characteristic action. The present experiments as explained in the the paper show that it is, after all, a temperature effect, speed being one of the factors determining the resultant temperature of the working surfaces. This can be visually observed in the disappearance of sparking (showing a high temperature of the rubbing surfaces) and the appearance of non-incandescent brake shoe metal ground off toward the end of the stop. Invariably the cessation of sparks and appearance of the non-incandescent metal dust are coincident with the beginning of the rise in the deceleration line referred to by Mr. Vaughan.

The question of complication mentioned by Mr. Vaughan and Mr. Thomson depends largely on the functions demanded of the brake. If simple and moderate functional performance can serve the purpose, complication of apparatus can largely be dispensed with. But if a multiplicity of functions, a high degree of protection against undesired action, and a high efficiency and effectiveness are demanded a certain amount of elaboration of the apparatus is necessarily implied. Mr. Turner has pointed out the requirements of modern railroad service which are constantly demanding more and more of the brakes along these lines.

It might be suggested here that the impression of complication is heightened by the multiplicity of lines required to illustrate the sequence and connections of the working parts of the valve device diagrammatically, and as if all in one plane. This by no means indicates an undue complexity of the device itself, however, partly because in the actual construction the connections can be made much more direct and simple than on a single flat surface and partly because ports and passageways once properly fixed in the metal do not create in fact the working complication suggested by the lines on the drawings.

The New York, West Chester & Boston tests mentioned by Mr. Potter are probably the best comparison of the action of one and two brake shoes per wheel which we have on record up to date. This is because the rigging effect was practically eliminated by reason of the use of the same rigging (with proper adjustment) for the single shoe tests as was used for the tests with two shoes per wheel. Thus, the tests fairly compare the action of one shoe with that of two shoes per wheel, without introducing the additional uncertainty of the action of two different types of foundation brake gear which is always present when testing differently designed riggings for clasp and for single shoe brake equipment.

With reference to the cause of the variation in train records mentioned by Mr. Sargent we would refer to the section on Check Runs and Averages, where it is shown that the length of stop varied from 1049 ft. to 1389 ft. No assignable cause for this variation has been discovered aside from the known difference in brake shoe bearing and shoe temperature. It therefore seems fair to assume that the different shoe metal conditions resulting from the different manipulations of the test train were capable of producing the differences observed. Moreover, by the same manipulation the same variation in the results could be reproduced at will.

The data submitted by Mr. Burton on braking force and wheel pressures disclose conditions of the greatest importance and significance. This phase of the situation deserves the careful consideration of all having to do with the design and maintenance of brakes and foundation brake rigging.

The per cent difference in stopping distance deduced by Mr. Burton requires a word of caution to prevent misunderstanding or misuse.

For electro-pneumatic brake operation the almost instantaneous application of the brakes makes it permissible to assume, as Mr. Burton has done, that the stops will vary inversely as the product of $e \times f_s$. But on account of the longer time occupied in reaching full effectiveness with pneumatic operation and especially if the performance of the PM brake equipment is being considered ($t = 2.5$ for PM equipment) more or less error is involved if the same assumption is made in such cases. The stops with the PM brake equipment, for instance, would all be longer than those on which the table was based and the influence of the time element (t in the formula given in the paper for length of stop) could no longer be disregarded as is the case when the stops are assumed to be inversely proportional to $e \times f_s$.

MEETINGS

SAN FRANCISCO, SEPTEMBER 10

The San Francisco Section held a quarterly meeting on September 10, at which a lecture by John A. Britton on the Lake Spaulding Dam of the drum hydroelectric installation recently put in service. This dam is at present 235 feet high and will ultimately be raised to 305 feet. The lecture was presented by H. C. Vensano and J. Jollyman discussed the mechanical and electrical features.

CINCINNATI, SEPTEMBER 17

A meeting of the Cincinnati Section was held on September 17, the address of the evening being upon the subject of Electrical Wires and Cables, given by Charles R. Sturdevant of Worcester, Mass., connected with the engineering and educational departments of the American Steel & Wire Company. The speaker laid special emphasis upon insulating materials, explaining at length how the three materials commonly used for insulating electrical wires and cables, viz., rubber compound, saturated paper and varnished cloth, are made and how they are applied, and how these in general need further protection by braiding, sheathing, or armor. It was further shown how the finished cables are tested, the effect of heat upon the electrical properties, and the energy losses in cables in service. Mr. Sturdevant showed an unusually fine collection of samples of these cables in which the audience was much interested.

PHILADELPHIA, OCTOBER 8

A joint meeting with the Franklin Institute was held by the Philadelphia members in the hall of the Institute on October 8, with a paper by J. E. Johnson, Jr., of New York, on Recent Developments in Cast Iron Manufacture. Mr. Johnson discussed the general results of carbon, silicon, sulphur, phosphorus, oxygen and manganese in cast iron. In connection with carbon, he considered particularly the effect of the shape of the crystals and the form of crystallization, which are not shown in the iron-carbon diagram. He outlined investigations made at the Ashland plant of the Lake Superior Iron and Chemical Company, in which it was disclosed that the presence of oxygen accounted for the superiority of charcoal iron over coke iron. He further described experiments made to introduce oxygen and convert coke iron into a product he considered superior to charcoal iron, and gave the physical properties of an iron of the composition of combined carbon, 0.85 per cent, graphitic carbon, 2.65, manganese, 0.26, phosphorus, 0.326, sulphur, 0.039, silicon, 1.25, oxygen, 0.50. Photomicrographs of the structure of this iron were shown.

A discussion of the paper followed.

BOSTON, OCTOBER 14

The first meeting for the season in Boston was held on October 14, the subject of the evening being Means and Methods of Measuring the Flow of Fluids in their Application to Industrial and Engineering Problems.

Three types of apparatus in most common use in connection with the handling of water, oil, steam, gas, etc., were described, Frederick N. Connet, chief engineer, Venturi Department, Builders Iron Foundry of Providence, describing the Venturi Type; E. L. Brown of the General Electric Company, Boston, dealt with the Pitot Type; and D. R. Yarnall, treasurer, Yarnall-Waring Company, Philadelphia, took up the Weir Type. The remarks of all three were illustrated with lantern slides.

Mr. Connet presented a chart showing the development of the study of hydraulics and the theory of freely falling bodies, tracing it back to the time of Leonardo da Vinci, about the year 1500. He showed that to Toricelli belongs the credit for the formula, V varies as the $\sqrt{H}$, and to Bernouilli, about the year 1700, is ascribed the establishment of the formula, $V = \sqrt{2GH}$. The principle of the venturi meter was brought out by Venturi in about 1800 and Herschel later adapted this principle into the venturi meter itself, giving it its present name. The slides shown by Mr. Connet displayed meters all the way from 1½ in. to 17½ ft. in diameter and also the 36-in. meters used at the World's Fair in 1893, by the use of which a large and unexpected leakage was checked. He called special attention to the fact that pulsations must be removed and showed methods for overcoming this difficulty.

E. L. Brown devoted his remarks to the flow meter of the pitot type extensively used for measuring the volume of steam.

D. R. Yarnall described the Lea V-notch recorders, both single and combined with feedwater heaters, and explained that the principle of operation was based on Thompson's formula for the V-notch. Methods of computing from the records made by the instrument were described. He called attention to the use of blowdown meters, the readings from which are to be deducted from those of the supply meters to show the net evaporation. These meters are used in a big plant to indicate any leaky blow-off valves.

In the discussion which followed, R. E. Dillon described a St. John orifice meter and J. F. Vaughan gave experiences with meters that had come under his observation. Sanford A. Moss dealt with the measurement of the volume of air issuing from blowers, air compressors, etc. About 150 were in attendance.

CINCINNATI, OCTOBER 15

Prof. F. R. Hutton addressed the joint meeting of the Engineers Club and the Cincinnati Section of the Society on October 15, upon the Testing of the Motor Vehicle. He urged among other things the abandonment of the word automobile and the substitution of the more inclusive term motor vehicle. His address covered four main points, the reason for testing a motor vehicle, where and by whom such tests should be made, how the motor-vehicle engines should be tested, and what results might be obtained from such tests.

A motor is tested for economy and efficiency, and may be tested on the road or on power measuring apparatus within doors; it may be tested by its designer and builder when new, or by its owner after it has been in use.

Professor Hutton illustrated the ways of testing by a large number of lantern slides, showing one of the best testing installations of the world, at the Automobile Club of America. A number of curves were given showing the plotting of the results of scientific testing. He made also a plea for good roads, illustrating bad roads by slides. There were more than 100 in attendance.

PANIC ECONOMIES AND EMERGENCY PROBLEMS WITH ESPECIAL REFERENCE TO THE PRESENT INDUSTRIAL SITUATION

BY F. A. WALDRON, NEW YORK

Member of the Society

PANICS, business depressions or financial stringencies are primarily due to the suspension of credits in one form or other. From eighty to ninety per cent of the business in this country is done upon a thirty to ninety days' credit, and where a condition arises which causes a disturbance of these credits, naturally there is a rush to conserve, or hold cash, and be prepared for any unusual demand that may be made for coin of the realm.

Many theories have been advanced as to the repetition and psychology of these depressions, all of which have been more or less exploded in the last ten years.

Securities, or collateral, in themselves are credits of indefinite amounts on which the borrower agrees to pay a certain interest. These are termed investments in which the accumulated cash or credit of the individual are transferred from financial institutions to the purchase of such securities. These again appear as credits when banks loan on them a per cent of their value.

Securities, like any other commodity, have a fluctuating price aside from their interest-bearing value largely dependent on the supply and demand. On gilt edge securities in prosperous times, financial institutions will loan from seventy to eighty per cent of the market value. When an emergency arises demanding the coin of the realm or gold payments on all business transactions, there is a rush on the part of those holding securities to turn them into cash. This rush naturally floods the market and causes a serious drop in prices which in turn require the banks to demand payments to protect resources and cash loans on such securities. This is termed "the calling of loans," in which the one borrowing is obliged to pay the borrowed money in cash and receives in return his securities. If this payment cannot be met, the securities are immediately sold, which increases the supply and helps the downward trend.

The above is what might be termed the initial suspension of credits in which long term credits are suspended at their source and its effect on the entire industrial situation is generally widespread and harmful, as it affects commercial paper issued by industrials in obtaining ready cash for payrolls and materials.

This results in curtailing expenses by purchasing materials in smaller quantities and reducing payrolls, which in turn produces another reactive and accumulative feature, as each person thrown out of employment reduces the purchasing power of a community, curtails the amount of money in circulation and affects directly the volume of business done. Therefore, when these persons are unemployed, they are dependent on odd jobs at reduced rates, savings banks deposits or other small investments, the kindness of friends and relatives, and, in many cases, all club together and reduce living expenses to a minimum.

To meet the demands of depositors in savings and other banks or holders of securities in small amounts, it is necessary that financial institutions conserve cash to meet demands and hold heavy cash reserves. Therefore, when a depression or panic starts, it is like a cyclone, as there is added to the pressure or velocity of the wind, the falling weight of houses or trees upon those that are standing in its path, and only the strongest are able to resist. Channels of circulation are then narrowed down, credits withdrawn and the efforts of financial institutions are concentrated and localized in order to meet demands upon cash reserves demanded by depositors.

Realizing that the savings banks deposits of this country are about $1,500,000,000, in amounts of one dollar to $3,000, the result of 2,000,000 men drawing from these institutions at the rate of $10 per week each, will give some idea of the amount needed. Most of the money thus withdrawn finds its way back to usual channels of circulation, but the "volume and rate of flow" is greatly reduced, resulting in tight money and slow collections.

In considering scientific adjustment of industrial finances during times of depression, there are a few elementary facts that control, all of which can be enlarged upon, almost to infinity. It is the purpose of this paper to place before you a few principles, leaving personality secondary; and if correct assumptions are made, the personal equation can be adjusted closely and satisfactorily with practical and reasonable accuracy.

The present situation has been suddenly and without warning forced upon us and we are at present facing a "condition and not a theory." That there is something wrong we all know, but what is it and how can it be remedied or made the least harmful, and what lesson can we learn? The question now is how to meet it and the problem is how can a recurrence be less harmful in the future.

Paper presented at the New York local meeting of The American Society of Mechanical Engineers on Oct. 21, 1914.

To meet the question requires immediate and drastic action in most cases, but this action should be taken with due care and scientifically lest the pendulum swing too far. This is the industrial age in which products of the base metals are paramount and any permanent setback will be sufficient to stop the wheels of progress for some years to come. Therefore, it should be emphasized that whatever is done should be done scientifically with a broad spirit and a regard for the future.

There has been a decided tendency in the last few years for our industries to take too liberal view as to future possibilities, and instead of storing up in their organization kinetic energy by impartial and broad methods, stock dividends have been declared, and large and extravagant buildings have been erected without regard to the maximum possibilities obtainable by a broad and flexible common sense management and the natural healthy growth of the market conditions. In fact, some are or have been hypnotized by " systems " until it is hard for them to find out where they are at. Many believe that when a system is installed that is all; but a system, however good, is dangerous unless it has at its head a man with broad experience and hard business common sense. It is in just such emergencies as the present one that such a man is the most valuable and saves his salary many times over, and those who have not such are now feeling the greatest pressure.

In order that a preliminary survey may be made of the condition confronting an industry, the following facts should be determined as closely as possible:

1 Duration of period of depression and earning power;
2 Attitude of banks towards you and their condition;
3 Resources and liabilities;
4 Cash on hand and available;
5 Realization of cash from resources;
6 Attitude and condition of competitors;
7 Possibilities of market by reducing prices;
8 Flexibility of organization.

The extent of a *period of depression* is placed first as the net resources divided by this time regulate the daily or weekly expenditures.

The *attitude and condition of banks* directly affects resources, as excessive rates of interest, refusal to loan on commercial paper or collateral, in usual amounts, means a serious reduction in net resources, as it not only affects you direct, but also your debtors and creditors.

Resources and liabilities are then largely dependent on items 1 and 2 as to the amount and time.

As 90 per cent of the business in this country is done on credit and is effected by items 1, 2 and 3, the *cash on hand and available* becomes the next in importance and blessed be he who has enough " to keep the wolf from the door."

In business as well as private life, the cash in hand is small in proportion to the amounts required to conduct business or live. Therefore, the next step is *realizing* on commercial paper, collateral and other security.

Having determined how internal and outside influences will affect the financial question, it can generally be assumed that most *competitors* are in the same position, but not always. It is his preparedness to continue business that will influence the rate of operation and the reducing of salaries, wages, and material costs, as very few people care to lay off in the most depressing periods, men who are indispensable to their organization.

Some enterprising firms have gone out in times of depression, *reduced prices* and compelled purchase of their product. While this has kept the wheels turning, it has also stocked up the market and simply defers the recovery of normal prices.

In economizing in item No. 5, efficiency as a workman should be considered first and where efficiency is equal, married men should be given preference. Where records of performance are kept, this becomes an easy task and is less likely to be unfair than where personal influences of foremen or gang bosses are the criterion of retention of employees.

The reduction of salaries is a delicate question, as there is no measure of efficiency other than the general results; these results are oftentimes absolutely dependent on the judgment of the ability, knowledge and personality and capacity for growth and time of employment. It may also involve a question of contract or the demand by competitors for the services of the individual. This situation is generally handled with temporary reductions by mutual consent of both parties, such reduction to be restored when times will warrant.

Frequently an executive can make a good showing the first or second year, but he has sacrificed other things to do it and the ensuing years show a drop which is so well covered as to be hard to locate, and the process of applying the remedy is involved and difficult. Sometimes it is a gradual running down of quality resulting in heavy expense for travel and trouble of investigation. I know of one case where it took thousands of dollars and five years for a company to gain the prestige back that it lost in two years of so-called factory management, in which rates were indiscriminately cut and the quality of work thereby slighted.

Flexibility of organization is last but not least, on the list. With proper arrangement of duties and the training of chiefs of divisions, superintendents and workmen, the contracting of the working force be-

comes easy, not only from a financial standpoint, but an equitable one.

After the conditions of resources have been carefully reviewed and considered, the present rate of expenditures should be tabulated in detail and shown graphically, under the following headings:

A Executive—including salaries of all officers of the company; fixed corporate charges.

B Sales—including advertising, development work, managers, salesmen, traveling expenses, rents, etc.

C Manufacturing—including all fixed charges, such as rent, taxes, depreciation, etc.; all non-productive wages; all productive wages.

With resources determined and present rate of expenditure and the time which the depression is likely to last, a rate of reduction is determined which is to be applied to each of these three divisions, in proportion to the value of the services in each, eliminating all expense not absolutely required to conduct business through the depression. The best way to approach this is as follows:

a Eliminate all work which is not profitable, such as inventions, new product, new design, indiscreet advertising, traveling expenses;

b Cut down, if necessary, working hours, especially where it relates to reserve stock on hand, working on orders only;

c Study the possibility of combination and rearrangement of duties in executive, sales and manufacturing;

NOTE: *Flexibility of organization* is very helpful at this point.

d Temporary reduction of executive salaries;

e Temporary reduction of all salaried employees, receiving above a certain amount ($100 per month is the usual limit);

f Reduce the number of non-producers to a minimum;

g Reduce the number of producers;

h Reduce wages (to be avoided if possible).

Having reviewed the causes and effects, let us now analyze the best way of meeting the question of reducing number of employees, by a fair valuation of service and a consideration of the influences at work to retain or discharge an employee with the idea in view of obtaining the most efficient results and of being just.

Influences: Influences as to the retention of employees are often inductive and subtle when analyzed, much more so than most employers care to admit in public, and may be classified as follows: 1, Nepotism; 2, Sentiment; 3, Influence and friendship; 4, Politics; 5, Lack of inertia (laziness); 6, Misguided judgment; 7, Improper placing of individual; 8, Technicalities; 9, Disease and old age; and 10, Ability.

Ability is placed last, as the others are generally mentally formulated and cause a plus and minus sign to be affixed to it. If a man gets "in Dutch," it is easy to find some excuse to "fire" him.

Kinetic Energy of Production: In principle there is very little difference between the demands made on the manufacturer of a commodity and a public service corporation as each, in order to be successful, must be prepared to meet promptly and efficiently at reasonable profit the demands of the consumer. The manufacturer may well study the public service corporation and obtain many helpful points in keeping investment in plant down and yet be able to supply the peak load demand.

The old plan was to have large plants and investment with ample margin for peak loads, which resulted in heavy depreciation charges, increasing cost of power as the load factor was low. This is now changed. Turbines and generators are put in to stand an overload; boilers are placed with regard to economic fuel consumption for average load with organization and facilities for forcing boilers at time of peak load to twice their normal capacity or more, by auto stokers, forced draft and high grade coals. These elements of quick response to urgent demand might be termed the *Kinetic Energy of an Organization*, and applying the parallel to industries, we have roughly the following:

a Specific assignment of duties to men and machines;

b Currency of tools;

c Flexible methods of detail accounting tied in with manufacturing;

d Uniformity of machine tools, to receive jigs, cutters and fixtures;

e Preparation of methods for compensating labor;

f Maintaining buildings and equipment in first-class condition that have to do directly or indirectly with the turning out of product; and

g Accessible supply of raw materials.

Items *a* to *f*, inclusive, are within the control of the manufacturer. Item *g* should be looked at from a broader viewpoint. Manufacturing is a business on which a reasonable profit is expected and yet many firms make, while more loose, on speculative buying of pig iron, copper, tin, zinc and other raw materials.

a—Specific Assignment of Duties to Men and Machines: The duties of various executives of important and minor responsibilities should be studied carefully and arrangement made by which these duties can be analyzed. From this analysis the ones that are absolutely necessary should be kept in mind and the unimportant ones eliminated. From this, duties can be assigned and rearranged and the working force reduced, either by the laying off of those not required or temporarily reducing them to the ranks until such time as business may warrant reinstatement.

The capacity of machines should be carefully studied, together with the operations, and such operations assigned as will enable one man to run as many machines as he possibly can with a view of obtaining

the proper quality of work at a reduced rate and reduction in the number of the working force. This is a most important item and should be studied with the idea of making the changes in such a way that they will admit of prompt rearrangement and enlargement as business demands increase.

b—Currency of Tools: One of the most defective points to-day in the development of the kinetic energy of an organization is the lack of supply, arrangement and assignment of tools, jigs and fixtures. Special effort should be made to study production and see that the standards, methods of making tools, stock carried, etc., should be such as to insure the continuous operation of the machines on which they are used.

c—Flexible Methods of Detail Accounting Tied in with Manufacturing Processes: A flexible method of detail accounting devoid of red tape and arranged so as to give the most efficient factory operation, is of paramount importance when a period of depression appears. If the method is flexible, it allows of prompt elimination of numerous clerks without interfering with the accuracy of the data which the proper shop accounting method gives. It also eliminates at all times unnecessary red tape and influences the manufacturer to study closely and scientifically the requirements of his factory by a simple review of manufacturing and stock records.

d—Uniformity of Machine Tools: This item is probably one of the most important, as it affects items *a*, *b* and *c*. By having uniform tapers, width of tee slots, speed and feed mechanisms, counter shafts, etc., alike, it enables the manufacturer to respond promptly to an increased demand and also to spread work over a large number of machines operated by one man in times of depression.

e—Preparation of Methods for Compensating Labor: With the four items above carefully arranged, it becomes comparatively easy to outline the best rates, premium and bonus methods readily adjustable to business conditions.

f—Maintaining Buildings and Equipment: If buildings and equipment are maintained to the highest degree of efficiency during strenuous times, oftentimes during a period of depression the expense involved can be eliminated, provided that this depression does not last too long, but it should not be carried to the point where the property has run down too far and requires a large amount of time and money to bring back to a proper stage.

g—Accessible Supply of Raw Materials: If a factory is remote from the supply and transportation companies and the latter are slow in making deliveries, it is quite necessary to carry a large amount of reserve raw materials in stock. To those that are near supply points, however, it is possible to reduce the amount of materials carried to a minimum and buy on short notice such materials as are required for plant operation.

The six items above mentioned, if carried to reasonable perfection, place a factory in condition of preparedness and the maximum amount of *kinetic energy* is available in an organization, leaving the question of materials on which the work is to be performed to complete the problem.

Stock on Hand: Having decided on readjustment of duties and schedule of working hours, rates to be paid and reduction in working force, the problem of turning quick assets of the business into ready money is a much more difficult one. Shrinkage in values of the natural products, such as pig iron, copper, tin, leather, zinc, etc., are such as to make wholesale sacrifices in prices almost impossible unless this shrinkage be offset by reduction in overhead and labor charges.

Articles showing least shrinkage in materials costs should be pushed and sold as rapidly as possible unless there is an abnormal profit on articles where materials show a greater shrinkage. All doubtful stock should be sold as scrap and turned into cash. Work in process should be finished and shipped at once, beginning with that which has the least labor to complete and working down to orders just started. Profit and ability of purchaser to pay promptly in cash should also guide in this.

Efforts should be made to get business of some kind to fill your plant, even if it is a little out of the regular line and somewhat special. With an oversold product and output, special work is not wanted, but with an output undersold to point of no profit or actual financial loss, special work will help absorb the overhead; further, if we expect to obtain foreign trade, we must furnish what they want and not what we think they ought to have. To accomplish this, it is quite necessary to have accurate records of costs and selling prices and a curve should be plotted showing how far reductions in price can be carried, bearing in mind that when overhead has been absorbed for the period of depression, gross profit turns to net, or, if it is impossible to do this, look at the curve with the idea of reducing overhead to correspond to reduction in business so you will break even or with a minimum loss. See the curve in Vol. 34, of Transactions of The American Society of Mechanical Engineers, page 1193.

Purchasing: There is no doubt but that a good purchasing agent saves his salary directly or indirectly, but in the case of the average-sized plant, where the volume of business does not warrant a purchasing agent, such plants could obtain the benefits of wholesale purchasing and keep in touch with the market by combining and hiring one good man to purchase all supplies and materials. The same applies to stock-keeping methods and stock handling.

Some, if not all, would say that this is impossible. True it is if that is the mental attitude, but, from an

economical and business standpoint, it is not, and would compel the training of sidesteppers who are evading their real responsibilities, to use more care and energy in their work and eliminate what is termed "shop politics" in organization. Truth and facts can be dodged for a while, but in the long run they will corner the dodger.

If the rate of production of all raw materials for manufacture could be brought to an even basis, either by arrangement or a fixed valuation basis, accumulation of stock on hand of raw materials, work in process or finished, that have accumulated with copper at 16 cents would not shrink in value 33 $^1/_3$ per cent when the price of copper dropped to 11½ cents.

If our banking systems at large were more favorably disposed towards, or valuations fixed, these speculative losses and hardships would be eliminated and it would be unnecessary for individual manufacturers to carry so much raw stock. If materials were handled the same as money and distributed from territorial storehouses as requirements demanded, this burden would be equalized and carry with it a much more stable condition of market.

This has practically been done with steel. Why should it not be done with cotton, wool, copper, tin, zinc, lead, etc? It could be done if sound and broad business methods were substituted for the speculative craze of the individual who lives by his wits at the expense of some loser, and these conditions would become more stable.

Engineering Service: Many firms have an engineering organization for the supervision of power and plant work and the design and construction of buildings. Where operations are on a large scale this is undoubtedly the most convenient method, but not always the most economical, as there is a tendency towards extravagances and oftentimes the buildings cost much more than to have this work done by an engineer with much broader experience.

In times of depression a number of factories could get together and retain an engineer for much less than their organization is costing even though the per diem charge for work is greater, but they would be receiving a broader and more efficient service. There are very many shrewd business concerns in this city that do this and their total bills for a year amount to about half what the engineering organization is costing companies doing less business.

Lessons to be Learned:

1st: That the world is growing smaller;

2nd: That nations are more interdependent for internal financial and industrial prosperity;

3rd: The more civilization advances, the more nations coöperate in this advance;

4th: The lessons of thoroughness and preparedness are driven home;

5th: That this country is deficient in merchant marine;

6th: That shipping and banking facilities with countries which are used as a basis for the Monroe Doctrine, are controlled by the English, French and the German;

7th: That our factories are not prepared to meet the demands of trade for such countries;

8th: That the mental attitude of taking what is made "or leave it," must be changed if we expect to obtain and hold the trade of other American nations;

9th: That whatever the outcome of this war may be, it will be the engineering of the past forty years that develops the successful nation.

In prosperous times we go on in the even tenor of our ways and live our own lives as to personal and business expenditures, some saving systematically, others always living up to and beyond their income. Conveniences and luxuries which appear as necessities when the income account is liberal, appear as extravagances when the income account is suddenly reduced. The platitudes and complaints of our troubles in prosperous times are loud and numerous, but let depression come on apace and we become meek and chastened, thankful for small favors and more content with our lot and sorry for those who are infinitely worse off than we are.

So panics and depressions have their good points in at least giving us a chance to look around and see how much we can get along without, to inspire economies and less wasteful habits, to allow the physical and nervous system a diversion and rest, to make us more thankful for what we have, and, last but not least, more thoughtful and considerate towards others, thus building up character to a higher and nobler plane.

DISCUSSION

William Kent: After the Civil War it was thought there would be a great depression in this country owing to the discharge of so many men engaged in the activities of war, and putting them into channels of business. But they went back to work again and produced wealth faster than it had ever been produced before. Then followed an era of speculation and of rapid railroad building. Suddenly, in 1873, like a bolt from the blue, came the failure of Jay Cooke & Co. and the long five-year period of depression set in. We were paying $1.75 for common labor at that time in New Jersey, and inside of one year the same men were glad to get 87 cents a day.

The first thing that happened when the panic set in was to throw men out of employment, and the second thing was to put those men at work at 87 cents a day. The depression lasted five or six years. It lasted so long that people got accustomed to it and thought it was a normal thing. In July, 1879, I went into the steel business, when we were sell-

ing pig iron at $14 a ton. Then suddenly people woke up to the fact that the depression was over, that the country was short of pig iron, and the boom of 1879 was started. The same steel billets that I sold in July for $60 per ton I sold the following January at $110. In July we were selling pig iron at $14, and in January at $40 a ton. If we do not look out, we will get caught the same way again.

In 1893 we had another panic, followed by another five years of depression. As to what we should do in times of depression, let me say that after the panic of 1893 I visited the Baldwin Locomotive Works, and at that time the normal payroll was about 8,000 men. But then they had only about 800 men at work, one-tenth of the normal payroll, and the works were whitewashed and looked like a cemetery. They had reserve capital, so could wait patiently for better times.

During the panic of 1907, one of the smaller ones, when most people were pretty blue, I met one of the leading manufacturers of machine tools in New York, and asked him if he felt alarmed over the business prospect. He replied: "Mr. Kent, I never sell the United States of America short." I visited his big machine works and found them fairly busy. I asked the superintendent, "Are you doing all this work on orders?" "No," said he, "we are working on stock. There is a quarter of million dollars worth of goods piled up there at the end of the building. It will all sell at good prices in a year or so." And it did. That is the kind of courage we want now. We must not shut down production if it can possibly be helped. The danger is that the present depression will be followed by a sudden boom, and carry prices too high if we have not got stock on hand to meet the sudden rush which follows the panic.

I had occasion to write an article on pig iron two or three months before the panic of 1907, when pig iron had dropped from $25 a ton to $24; and people began to wonder whether it was not going to rise. I said that $25 is a danger signal, and pig iron will not rise again until it goes to $17 a ton. The editorial department thought I was crazy, and they were not going to publish the article; but they finally published it, and pig iron went down to $15 before it started to recover. When pig iron is $25 a ton, it must go down to $15. And when pig iron is $10 a ton it must go up to $15 or $20 at least.

Our farmers are doing very well, and people are wearing out shoes and clothes all the time, and they will need more when the present ones are worn out. The general business of this country, the production and consumption of foods and cars and building railroads and houses should go on; things are being worn out and they must be replaced. If we do not arrange to replace them soon, we will have to replace them later, and at higher cost. That is the boom period of unduly high prices. Begin to replace those things now.

In regard to this banking trouble, I am in harmony with what Mr. Waldron said. I think one of the troubles of this country is that the bankers and financiers have not yet learned the true principles of finance. The psychological condition President Wilson spoke of, is an absolute fact. Nervous prostration is nothing but nerves; but it is a serious condition that throws the whole system out of order.

Why can't we get money? Go back to the Civil War, when the question was, how could that tremendous war be financed when everybody was scared and the bankers were locking up money. The Secretary of the Treasury went to Wall Street, and the Wall Street bankers named their terms for a loan, and they said that was their ultimatum. The Secretary of the Treasury said: "Gentlemen, it is not the bankers of the nation that make ultimatums. It is the Government of the United States that makes ultimatums. And if you do not make this loan we will issue money, emergency currency, so much that it will take a basketful of it to buy a breakfast." And the Government issued the greenbacks. Finally it struck the bankers that they had gotten in wrong and they were glad to buy the Government's 7-30 bonds. Now the bankers are learning something. They take out clearing house certificates and emergency currency to tide them over the time of trouble; but yet they say "it is inflation, and the people will get extravagant." The people do not get extravagant in panic times, when this emergency currency is being issued, but in times of inflation following good times, when credit is good; and there is no reason why we should not have emergency currency to tide us over panics or periods of depression. I believe the bankers are all wrong with this whole idea of holding tight to a twenty-five per cent reserve during panic times. It is all right under ordinary conditions to have a twenty-five per cent reserve. If you engineers build a reservoir for supplying a city with water, you would not expect the city government to pass a resolution that twenty-five per cent of that water must always be kept in the reservoir, and that we could not use water when it got down to the twenty-five per cent level, for when a big fire or a long drought comes we will draw water until the reservoir is empty, if necessary. Why do we want to keep a reserve in the banks? "Because the law says we must," is what the banker replies; "if we do not, some State official will come down on us for not having that much reserve." "What is the reserve for?" we ask the banker. "We must have the reserve there," he replies. "What is it for?" we ask. "It is to have a reserve."

It is a nice thing to have reserve money in your pockets. Suppose you say to yourself that you will never have less than twenty dollars in your pocketbook. What good would that twenty dollars do your pocketbook, if, when you needed it, you did not use it? The reason for the reserve is for the purpose of having the money when you need it to spend. But the bankers say, "It is a terrible thing to loan money on copper and cotton," as was suggested to them. I say, "Why not loan on copper and cotton just as well as you loan on gold? Suppose a bank would loan on copper certificates say at 5 cents a pound. Copper never sold below 10 cents a pound, so it would be perfectly safe to loan money on copper at 5 cents a pound and then issue emergency currency, and have it carry a discount of one per cent a month, so that it would not be held longer than was absolutely necessary. That would make twelve per cent a year." "That is terrible, that one per cent a month interest," they say. "But," I reply, "it would tide you over a month or two or three months of trouble." So nobody would hold that money for a year, as it would decrease in value at the rate of one per cent a month.

We have heard about the need of elastic currency for the last ten years. We are going to have the reserve banks; that will help us. Very good. We have gone that far, and some day we will get a more sensible set of ideas about these

emergency issues, and these United States can be carried on in periods of depression without any trouble or worry whatever. That same banker said, "We cannot loan money on collateral, because we haven't got the money. We have to protect our reserve." I said, "Where is all the money now? Is it hoarded up?" He said, "Yes; it is hoarded. Thousands of people are hanging on to their money."

A man told me the other day, "If you have any money in the bank, draw it out." I said, "If you have any money, put it in the bank and let the banker loan it out and get business started." I said, "If you are going to buy a suit of clothes next month, go and order it now; that will put the tailor to work. If you are going to build a house next year, start on it now. That will put a lot of men at work. If you have any debts and can raise the money, go and pay them off. If you owe a man a dollar, pay it to him, and it will float around and pay other men's debts. We want stimulation, and people putting the money in the banks and the banks being as liberal as possible, instead of as stingy as possible." That will tide us over this emergency. That is what should be done.

Selby Haar: Referring to one point of Mr. Waldron's conclusions, to the effect that it will be rather difficult for us to capture the trade of South America. I believe it can almost be stated as an axiom that our foreign trade will be the more profitable to us, the more closely we can adhere to standard goods, which are manufactured in quantities. At any rate, it should be most nearly true in the machinery trade which I have particularly in mind at present. We differ from all other manufacturing nations in that workmen's wages are high here, in consequence of which our standard machine is designed to reduce the labor cost of the article produced by the machine either by the principles according to which it is constructed or the attachments with which it is fitted. Our competitors, however, have not considered it necessary to manufacture machines for their own use which are so sparing of the attendant's labor, and for that reason they have developed lines of machinery of minimum manufacturing cost. We are seeking trade in South America and other countries which industrially are not as highly developed as we are and where labor is cheap, a fact that favors our competitors, as it weakens our chief argument in justification of the higher price of our goods. Moreover, since the standard article of the European manufacturer more nearly meets the requirements of foreign trade than ours does, our competitors can adapt their machines to meet the special conditions of different countries more cheaply than we can. Thus the argument of purchase price is likely to be against us.

To overcome these handicaps, let us, if necessary, offer new lines of machinery especially for foreign trade, utilizing such principles of operation and attachments as are indicated by a thorough study of the actual conditions of use. We cannot expect the South American or the Asiatic to conduct his business as we do ours, but with our manufacturing experience and inventive genius we can help him to carry on business in his own way more successfully, and in this competition of brains we can hold our own.

Frederick A. Waldron: In regard to the remarks of the last speaker, Mr. Haar (I will pass Mr. Kent's remarks, for I agree with him) it brings home to me an experience I had about a month ago. While what he says in regard to labor-saving, price, etc., the cheapness of labor in South America and other countries is all true, yet their unit cost of labor is higher. A gentleman came into our office five weeks ago in an indignant frame of mind. He came to the United States with $500,000 to purchase supplies (not machinery), such as nails, steel pipe, etc. He went to one concern, I think the largest in this country in its line, and asked for a quotation on steel-wire nails. The English practice is different from ours, as to the length of nail and weight of package. They require 112 pounds, while our standard package is 100 pounds. This large company would furnish them at a price; he also went to five other corporations running at forty or fifty per cent capacity, and asked them to furnish these nails of a given length put up in 112 pound packages. They replied, "We are very sorry, we cannot take the order; we don't make them that size, and we pack in 100 pound packages." Is not this high treason to American industries?

The same gentleman wanted steel tubes, wrought iron pipe size in 18-foot lengths. Receiving the following reply: "No, we cannot furnish unless you take it in 20-foot lengths," he replied, "Well, I will take them in two 10-foot lengths." They said, "No, you will have to take it as we make it or leave it."

Now, if tales of that kind get abroad, the effect is very harmful.

RECENT DEVELOPMENTS IN THE MANUFACTURE OF THE DIESEL ENGINE

BY H. R. SETZ, ST. LOUIS, MO.

Member of the Society

IT is my intention to emphasize fully the importance of a careful study of the engineering principles in general involved in the construction of oil engines of the Diesel type. It is a well-known fact that, compared with what has been accomplished with this prime mover in other countries, the United States has remained far behind, although conditions are in a large part of this country ideal for its extensive use. Aside from a number of other unfortunate circumstances, this condition is primarily due to a lack of appreciation of sound engineering practice.

There is hardly a problem that commands the attention of engineers at the present time more than that of the Diesel engine, which in certain fields at least, is giving an entirely new aspect to the manufacture of power machinery and to power-house engineering as well as to the commercial use of power. The importance of this problem is emphasized by the typical American aggressiveness with which the manufacture of this prime mover has lately been taken up since the expiration of the principal Diesel patents. If conscientiously pursued, with careful consideration of the most minute details, there is every reason to believe that this new enterprise will develop into one of the most stable industries. Signs are beginning to appear, however, indicating that this is not always being done. Merely for the sake of cheapness, practices have in some cases been adopted which, being evidently unconditionally taken over from gas engine and even steam engine experience, are of more than questionable merit.

The Diesel engine works under a maximum pressure of from 450 to 470 lb. per sq. in.; this is only 15 to 20 per cent higher than what is customary in gas engine practice. As far as control of the resulting strains in the various engine parts is concerned, no more difficult problems would, therefore, present themselves than in gas engine design. Unlike in the gas engine, however, it is imperative with the Diesel engine that this maximum pressure be attained with compression alone. Extreme accuracy of fits as well as alignment of the various engine parts must therefore be one of the first requirements in Diesel engine construction. This is not, as might at first appear, merely a shop question; the highest standard of workmanship cannot prevent rapid deterioration if unsuitable materials are used or features of design resorted to that result in excessive or unfavorable strains. Strength computations are only one part of the designer's work; a more important task is to study and if possible determine elastic deformations and their possible effect upon co-related parts. It is here where the designer's skill and experience manifests itself; by judicious distribution of material or form of constructive elements these deformations can be greatly reduced and transmitted in such a way as not to affect vital points of the engine. The unusual amount of painstaking work involved in investigations of this nature is well repaid by the satisfaction and insurance of having produced an engine that will meet the most exacting requirements. An engine built with such care will be as reliable as a steam engine and considerably simpler than the apparatus of a steam plant and the operator will be unaware of the high temperatures or pressures under which it works. In view of past experiences, this statement may sound Utopian to American engineers; nevertheless it is being proved daily and accounts for the fact that the aggregate horse-power of Diesel engines in operation today in European countries approaches the one and one-half million mark.

We are in the fortunate position of being able to draw from the wealth of information and experience accumulated during the last ten years in all these Diesel engine installations under the most varying conditions. This experience manifests itself in certain typical forms of constructional elements which have been found to give the best security for continuous service, even under adverse conditions. Information of this nature is accessible to every engineer through the technical press and I cannot but urgently plead for its careful study. By this, I do not wish to be understood to advocate blindly following practices which have been developed by one or two leading European concerns and adopted since then with very few modifications by later manufacturers. The cost of labor and its relation to the cost of raw materials are so different here from what they are abroad, that they invite certain departures from European practice. The ultimate aim, however, must be always a product which is first of all reliable; we must endeavor to incorporate those features which make for long life, not only under intermittent periods of operation, but under requirements such as have to be met with in industrial installations with as high as 144 operating hours per week.

As an example to illustrate this point, Fig. 1 shows a form of adjustable bearing which to many engineers

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still represents the ne-plus-ultra of mechanical perfection. With the pressures acting mostly downwards, the idea is to take up any wear in the lower box B by drawing up wedge W. Considering the fact that a slight clearance c must be maintained between shaft or pin and bearing to allow for lubricating oil, it can readily be seen that even under very best conditions, box B is always loose or floating between the moving shaft above and the wedge underneath it. That the latter, with its varying position according to adjustment and duty of transmitting all the forces acting upon box B, is not an ideal support for a bearing box, is quite evident. Utter lack of rigidity in the very direction where it is most required is therefore the first criticism of this construction.

An equally bad feature is the uncertainty of effective lubrication. Owing to the gap g between the two box halves which, of course, is necessary to facilitate

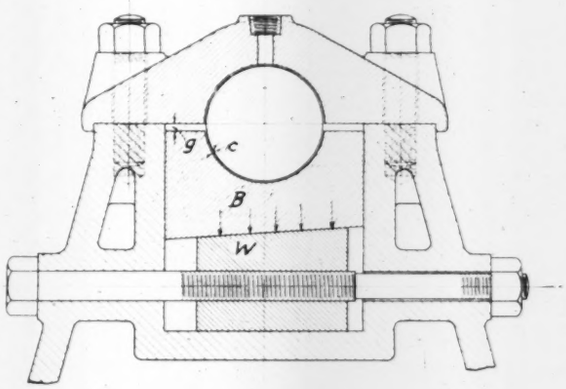


Fig. 1 A Generally used form of Adjustable Bearing

adjustment, a comparatively low bearing pressure, combined with the rotation or oscillations at the bearing surface is required to reduce the thickness of the oil film sufficiently to cause excessive wear. A third drawback, which applies to a great number of modifications of this form of bearing, is the danger of shifting in regard to the shaft or pin axis. This is brought about by the lack of adequate mechanical means and therefore impossibility to maintain absolutely with any degree of certainty true alignment, either in operation or while adjustments on the wedge are being made; an error of only a very few thousandths of an inch can cause disastrous results. In view of these possibilities, the use of any form of wedge adjusted bearings, either as crank shaft bearings or crank-pin and piston-pin boxes, is to be condemned; experience even on gas engines has shown that they lack all the essential features that insure reliability in continuous operation and this will to an even greater extent be true in Diesel engine practice.

Fig. 2 shows the form of bearing which has fulfilled all requirements of continuous service in a most successful manner. Rigidity is insured by the bearing shells being fitted over their whole circumference directly into the main structure without any intermediate parts. Furthermore, they are drawn down tight on each other by means of the bearing cap, usually with shims s between the joint, so that a continuous oil film of ample thickness can be maintained over the whole bearing surface. The pin or shaft is thus actually kept floating on oil so that wear will be reduced to a minimum. It is even conceivable that with clean lubricating oil and a proper lubricating system, wear might be entirely eliminated. Cases are known where Diesel engine main bearings of this form still showed original scraper marks after two years of operation. It is due to these features that accuracy and maintenance of alignment are insured to a degree not obtainable with any other form of bearing known today.

Vertical, moderate-speed four-cycle engines, with rotative speeds ranging from 150 to 200 r.p.m., and piston speeds from 650 to 750 ft. per min. are considered here as the one type which experience has proved

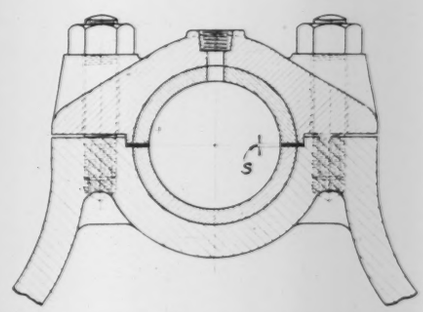


Fig. 2 A form of Rigid Bearing that satisfies Diesel Engine Requirements

to be more than any other adapted to meet successfully general industrial conditions in sizes up to 175 to 200 h.p. per cylinder. For very small sizes or installations where the load factor is low, two of the leading German makers have, within the last few years, developed a line of horizontal engines of the Diesel type. This form is somewhat lower in first cost and therefore better adapted for conditions where the fixed charges have to be distributed over comparatively few operating hours. Under these conditions, the inherent disadvantages of horizontal engines probably will not manifest themselves sufficiently to cause excessive maintenance expenses, although naturally experience extending over sufficiently long periods to furnish conclusive data is at the present time still lacking. The two concerns referred to above, although being the largest manufacturers of horizontal engines, have at the same time a far larger output in vertical units.

As regards vertical engines, distinction must be made again between the moderate-speed and the high-speed type, running anywhere from 200 to 400 r.p.m., with piston speeds ranging from 800 to 900 ft. per min. and more. These were brought out lately to meet

a demand for compact and light prime movers to be used as auxiliaries on board ships or as a standby for lighting, power and pumping plants, where space is limited. Unfortunately not enough information is generally available whereby a relation between most favorable operating conditions and rotative or piston speeds can be definitely established, but this much is known, however, that high piston speeds are decidedly detrimental to continuous satisfactory operation. It is only under conditions such as rather infrequent and short operating periods, therefore, that the high-speed engines can give a fairly good account of themselves and even then their depreciation is quite rapid.

The characteristic features of the Diesel cycle of operation cannot be more quickly grasped than by reference to the comparative indicator diagrams, Fig. 3, of a Diesel engine, a gas engine and a steam engine, all

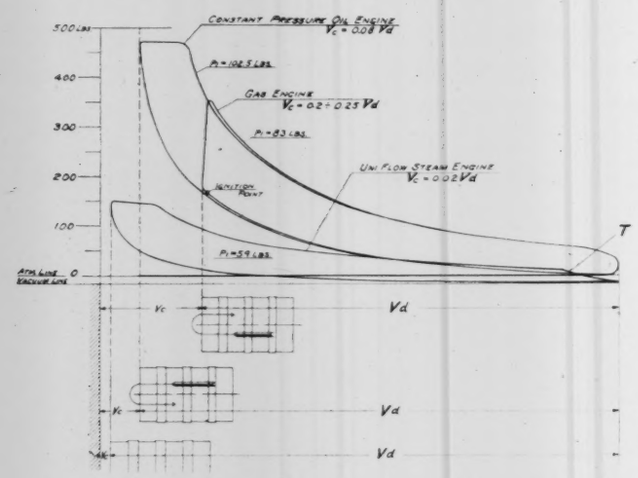


FIG. 3 COMPARATIVE INDICATOR DIAGRAMS OF DIESEL ENGINES, GAS ENGINES AND UNIFLOW STEAM ENGINES

three having the same cylinder volume. The steam engine diagram is characteristic of the uniflow engine, a form which permits the utilization of the whole pressure range of the steam in one cylinder in the most ideal manner. The similarity of this diagram to that of the Diesel engine is quite striking, except for the toe *T*, caused by the uncovering of the exhaust ports of the steam engine piston. The Diesel engine diagram shown is that of a four-cycle engine; in the card of a two-cycle engine, a similar toe would be apparent. The maximum pressures, while, of course, about three times higher in the Diesel engine, are in both engines obtained very gradually by compression alone, while in the gas engine the pressure at the end of the compression stroke is only about 160 lb., followed by a practically instantaneous pressure increase to 360 lb., or about 125 per cent. It can be seen from this that while the maximum pressure reached in the Diesel engine is about 15 to 20 per cent higher, the gas engine nevertheless works under less favorable conditions. In actual practice, this manifests itself in a distinct pound in the gas engine, which is not noticeable in the Diesel engine. Due to the higher compression, the clearance volume of the Diesel engine is about 8 per cent of the displacement volume, compared with 20 to 25 per cent in the gas engine. In the uniflow engine, with the steam exhausting into the condenser under a very low vacuum, the clearance volume is only 2 per cent of the displacement volume, although not all of the latter is available for compression, as the exhaust ports extend usually over about 8 per cent of the piston stroke.

Since Fig. 3 shows the diagram of the three types of prime movers over the same cylinder volume (at the end of the expansion stroke), it forms a ready means of comparison in regard to their specific work capacity. With the uniflow steam engine highest and the gas engine lowest, the proportions are about

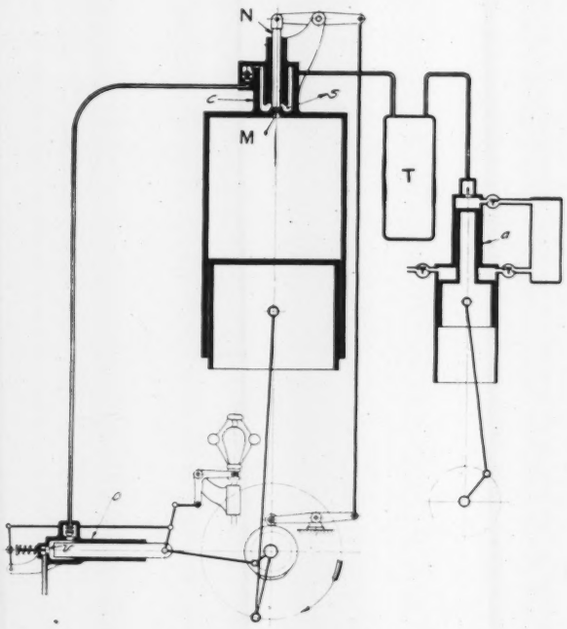


FIG. 4 DIAGRAM OF WORKING ELEMENTS OF THE DIESEL ENGINE

1.85 : 1.35 : 1.0. The four-cycle Diesel engine with its one working stroke against the two of the steam engine, is, therefore, a fairly close second, while a two-cycle Diesel engine, although its mean effective pressure is considerably lower than that of a four-cycle, leads the steam engine by about 18 per cent. This superiority of the two-cycle engine over the four-cycle in regard to capacity is quite generally understood and accounts for a rather widespread belief that the Diesel engine of the future will be of the two-cycle type. Unfortunately, however, this very fact of double the power strokes and double the heat influx through a given cylinder surface, introduces physical and mechanical problems of a complexity unknown in four-cycle engine work. In a two-cycle engine, the heat to be transmitted through one square foot of cylinder

surface amounts to approximately 90,000 B.t.u. per hour, as compared with about 10,000 B.t.u. in a steam boiler. In a four-cycle engine cylinder of the same size, the corresponding figure is approximately 40,000 B.t.u., i.e., less than one-half owing to the higher economy over the two-cycle engine. The overheating of four-cycle engines, when working under heavy overloads for any length of time, may well give some idea of what is happening in the two-cycle cylinders. If to this is added the extremely high mean bearing pressure which is continuously acting in the same direction and thus aggravates the difficulty of lubrication, it is little wonder that the two-cycle Diesel engine has so far failed to fulfill most of its promises, except for large, slow speed, stationary units.

Owing to their high mean temperature, any strains of the reciprocating piston, even those resulting from the weight only, have proved detrimental and must be kept away from the cylinder walls. This can be accomplished only in a vertical cross-head type engine with water-cooled pistons and even then experience has amply proved that nothing but the longest possible intervals between "heat impulses," i. e., slow speeds, will guarantee its success. Such features cannot be incorporated in engines below about 200 h.p. per cylinder without increasing their cost to a prohibitive figure. It can safely be said, therefore, that for anything like steady daily service, the two-cycle Diesel engine of small or medium size is out of the question. The reluctance with which these facts are accepted by those not thoroughly versed in Diesel engine practice is shown by one or two types of two-cycle engines that are conspicuous by their cheapness as well as poor engineering features. The temporary advantage gained by the cheap first cost is in a short time wiped out by the heavy maintenance cost and involuntary shutdowns.

The high compression of the Diesel engine as shown in the diagram, Fig. 3, indicates that there must be a fundamental difference between its method of operation and that of other forms of internal combustion engines. With the latter, it is a well known fact that the danger of premature ignition of the gas and air mixture contained in the cylinder during the compression stroke, limits the maximum compression pressure to a value far below that obtained in Diesel engines. In the latter, pure air alone is compressed in the engine cylinder, which, of course, at once eliminates all danger of premature ignition. The fuel is not brought into contact with this highly compressed air until the end of the compression stroke. From this the need for entirely new mechanical means on the Diesel engine, as shown diagrammatically in Fig. 4, is apparent. Aside from the usual cylinder and piston with admission and exhaust valves, each Diesel engine requires an air compressor *a*, capable of compressing air to a pressure as high as 900 lb. per sq. in. These air compressors have at least two, preferably three, pressure stages with effective intercoolers between each stage, so as to keep the air temperatures always as low as possible. From the last stage, the air passes to a receiver *t*, which is continuously in open communication with space *s* of the fuel valve cage *c* on the engine cylinder. Fuel oil pump *o*, under control of the governor, periodically delivers a measured quantity of oil corresponding to the load on the engine, into space *s* of the fuel valve cage. This oil, it will be observed, must be delivered against the high pressure prevailing in space *s*, as will be referred to again. As soon as the fuel valve *n* opens, the high pressure air will blow the fuel from space *s* into

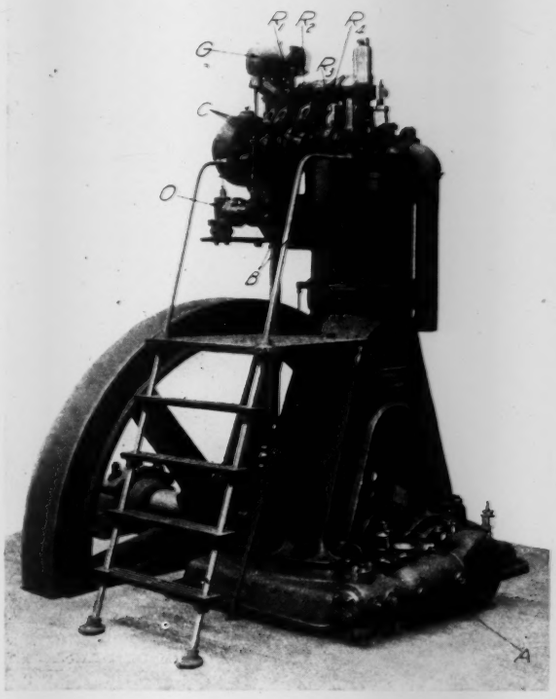


Fig. 5 An Example of the Conventional Type of Vertical Four-Cycle Diesel Engine

the engine cylinder where air has in the meantime been compressed high enough so that the resulting temperature will immediately ignite the fuel injected into it. This injection continues over about 10 per cent of the downward stroke of the engine piston in such a way that combustion of fuel takes place at approximately constant pressure (see indicator card, Fig. 3). The important function of the high pressure air compressor *a* can now be readily understood in that it furnishes the necessary medium to carry the liquid fuel into the engine cylinder against the high pressure prevailing therein; incidentally it also furnishes the air required to start the engine.

Fig. 5 shows an older form of the conventional type of vertical four-cycle Diesel engine, on which the arrangement of the principal parts just enumerated can

be clearly seen. The air compressor, A, is here mounted horizontally along the engine base-plate and driven directly from a side crank on the engine shaft and forms, therefore, an integral part of the engine; this is to-day the general practice on all modern Diesel engines, as it has been found to be by far the most effective arrangement. The vertical arrangement, as in Fig. 23, is, however, to-day given the preference, as it gives more satisfactory results and has, therefore, been adopted even for horizontal engines. The fuel oil pump, o, is mounted on the cam shaft bracket and is driven from the vertical shaft which transmits the motion from the crank shaft to the cam shaft. This same vertical shaft carries on its top the governor, G, which regulates the amount of oil to be furnished by pump o, although a somewhat simpler and neater arrangement for this governor is found on most of the latest forms of engines by placing it on the vertical shaft underneath the oil pump.

Fig. 5 gives also a good idea of valve gear arrangement. The cam shaft runs alongside the cylinder head and is supported on brackets B bolted to the engine frame, which permits the removal of the cylinder head without having to dismantle the cam shaft. With the cams C thus brought close to the valves in the cylinder head, the mechanism required to operate each valve reduces itself to a single rocker arm R_1, R_2, R_3 and R_4, and the absence of rods or any other intermediate parts thus insures maintenance of accuracy in the valve setting as well as quiet operation. As an additional insurance, some designers have lately completely enclosed the cam shaft in a continuous housing, whereby the cams and cam rollers can be thoroughly lubricated and dirt and dust kept away from them.

The accepted practice on all internal combustion engines for starting is compressed air, which suggests it-

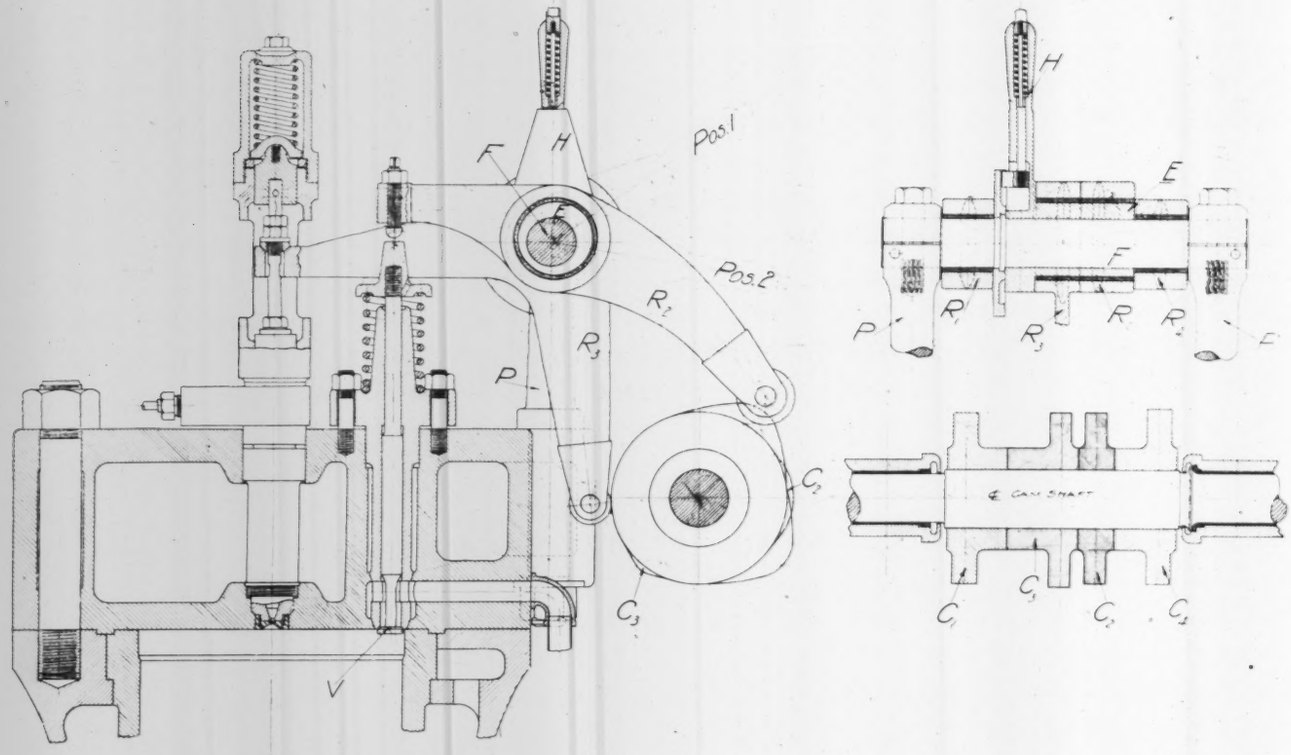


FIG. 6 DETAILS OF A FORM OF STARTING MECHANISM COMMONLY USED IN DIESEL ENGINE PRACTICE

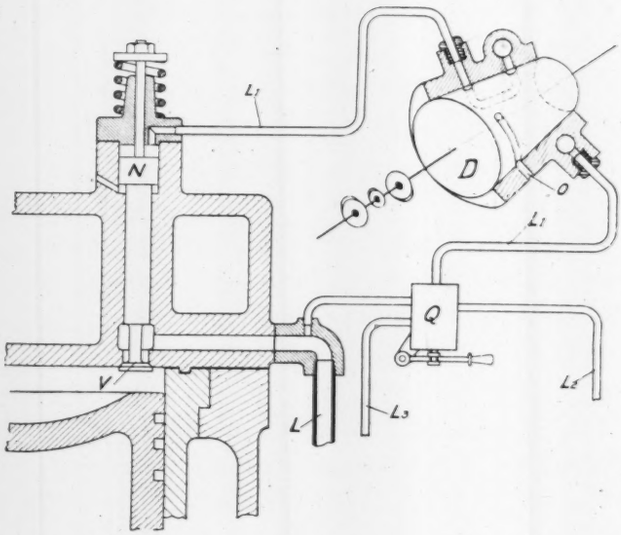


FIG. 7 A FORM OF APPARATUS USED IN MARINE PRACTICE FOR OPERATING THE STARTING VALVE

self all the more on the Diesel engine on account of the use of the high-pressure air compressor. The fact that air of a pressure varying from 700 to 900 lb. per sq. in. is needed to inject the fuel into the engine cylinder naturally suggests the use of air of this same pressure for starting and this actually is the practice generally pursued in modern Diesel engines. One or two large seamless steel receivers of ample capacity for several starts each are to-day used on every engine, these being kept charged with air of from 700 to 800 lb. pressure.

In the first stages of Diesel engine development in Europe, this high pressure air system had often been criticised as dangerous; now, since thousands of installations have proved their safety to exceed that of steam boiler plants, owing to the absence of high temperatures and the small pipes used, it is accepted as the simplest and most reliable system for starting. Nevertheless, schemes are occasionally brought out in which the high-pressure air system has seemingly been done away with by replacing both injection and starting air receivers with one tank, which is kept charged with air of about 200 lb. pressure. In starting, the engine is operated with air of this lower pressure until a sufficiently high air pressure has been built up in the injection air line to permit the injection of fuel oil into the engine cylinder. The high-pressure air compressor as well as the high-pressure air line to the injection valves are, of course, retained with this arrangement, so that the mere elimination of the high-pressure air receivers means a very small gain in regard to safety. A very serious drawback is introduced, however, due to the resulting absence of reserve capacity of compressed air. If it takes about ten charges of compressed air to build up the injection air pressure, it can be seen readily that with an initial pressure of only 200 lb. very little air will be left for another start if the first attempt should fail. Furthermore, the absolute dependence upon every stroke of the air compressor so as to prevent immediate reduction of the injection air pressure below that of the highly heated air in the engine cylinder, with resulting explosion in the injection valve cage and especially burning off of needle valves, does not greatly add to the reliability of this system.

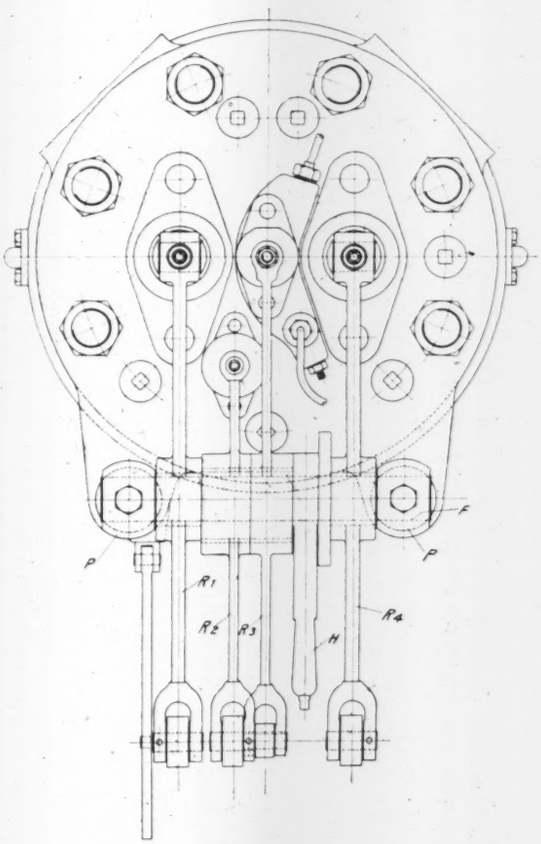


Fig. 8 Plan View of the Valve Gear shown in Fig. 6

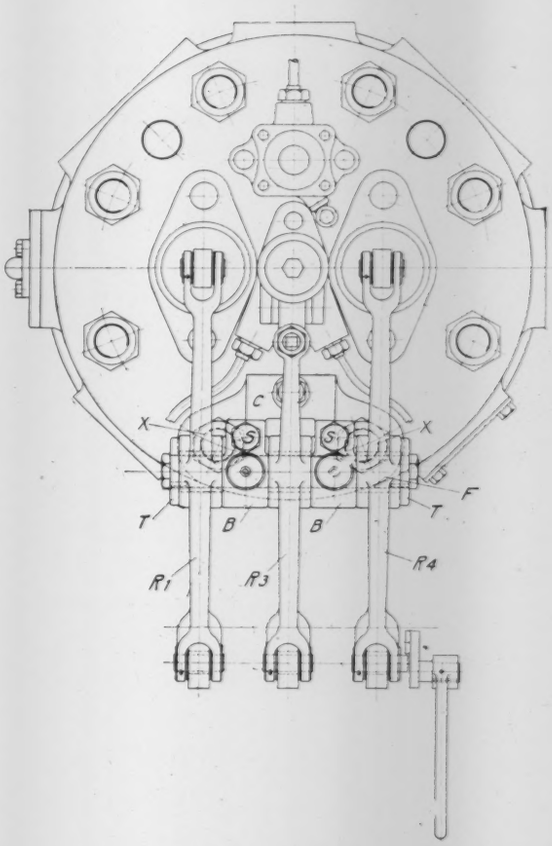


Fig. 9 A Modified Arrangement of the Valve Gear to Facilitate Removal of Rocker Arms

The customary arrangement on the engine to facilitate starting consists of a valve V, Fig. 6, which is mechanically operated by means of rocker arm R_2, and this, as well as the injection valve rocker arm R_3, are both mounted on an eccentric E, which is provided with the handle H. With this handle in the running

position, as shown in full lines in Fig. 6, rocker arm R_2 is raised sufficiently to let its cam C_2 pass underneath it without operating valve V, while rocker arm R_3 is in its normal operating position. To start the engine, handle H is turned 90 degrees into position *2*, when rocker arm R_3 is moved out of contact with its cam C_3, while R_2 now moves into operating position. With handle H in position *1*, neither rocker arm is working and the engine is thereby stopped. Valve V is made a balanced valve by giving its stem the same diameter as the valve proper, thus permitting the starting air to be turned on without causing it to open.

Induced by the requirements of marine practice for which the system just described does not lend itself as readily on account of the frequent maneuvering, several schemes have lately been devised whereby the starting valve is operated pneumatically. This permits a considerable simplification of the whole valve gear which, with some modifications, is applicable to advantage on stationary engines as well. Fig. 7 represents schematically one such system which has given very good satisfaction. Mounted on the same shaft with the cams is the rotary distributor D which, by means of suitable passages, periodically connects a chamber over the starting valve first with branch L_1 of the starting air line and then to the atmosphere through O. Piston N on the starting valve stem is thus acted upon to operate valve V the same way as was formerly the case with the rocker arm R_3. This starting operation begins as soon as the quick-opening valve Q is moved to admit air from the main starting line L into the branch line L_1; valve Q is so arranged that the engine can be started either from the platform or engine room floor at will.

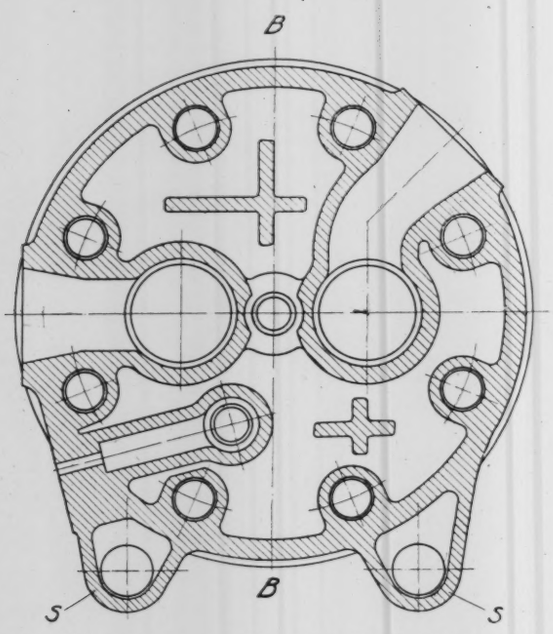


Fig. 10 Cross-section of Cylinder Head shown in Fig. 8

Here is an example where it has paid well to make a departure from conventional European practice. Aside from providing means for starting and stopping the engine either from the engine platform or engine room floor and thus eliminating one of the criticisms made against vertical engines, it has helped to considerably simplify the valve gear as Figs. 8 and 9 will show. Fig. 8 gives a top view of the valve gear shown in Fig. 6. R_1 is the rocker arm for the exhaust valve, R_2 that for the starting valve, R_3 for the injection valve and R_4 the one for the admission valve. All these, together with eccentric E and handle H, are mounted between the supporting posts P on fulcrum F (see also Fig. 6). It will be noticed that in order to remove any of the valves from the cylinder head the rocker arms with their fulcrum F must first be bodily lifted out of the supporting posts P. With the elimination of rocker arm R_2 and the handle H, a more convenient method of support could be adopted for the valve gear shown in Fig. 9. Here rocker arms R_1 and R_4 are mounted on the overhanging ends of fulcrum F, the latter being rigidly supported by the chair C between its two bosses B with the injection valve rocker arm R_3 in between them. Either rocker arm R_1 or R_4 can be easily withdrawn by taking off the end plate T, which permits quick removal of the admission or exhaust valve while the rest of the valve gear remains intact. Full access for removing the injection valve is obtained by loosening the two clamping bolts S in the chair C so that fulcrum F can be shifted lengthwise until rocker arm R_3 can be taken off. These modifications, although insignificant in themselves, are the simple short cuts which make proper supervision easy.

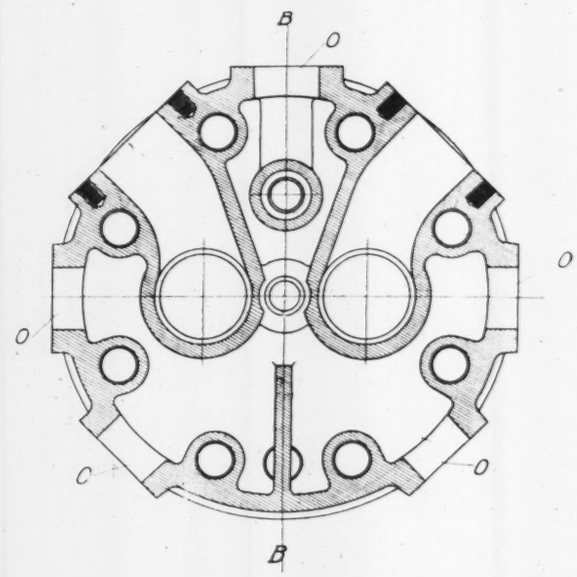


Fig. 11 Cross-section through a Cylinder Head of Symmetrical Design

Probably the most important, although least notice-

able, advantage resulting from this modified valve gear is the simple cylinder head construction. It is well known from gas-engine practice, that the cylinder head is one of the most delicate parts on the whole engine, and this is to a still greater measure true with Diesel engines where, owing to the higher pressures, although with temperatures slightly lower than in gas engines, extreme care must be paid to a suitable design. Aside from proper material which in itself requires considerable study, the first requirement is to obtain a casting which is as free from initial strains as possible. With our present knowledge very little can be done to determine these mathematically beforehand; the designer must here be guided by logical reasoning, based upon practical experience.

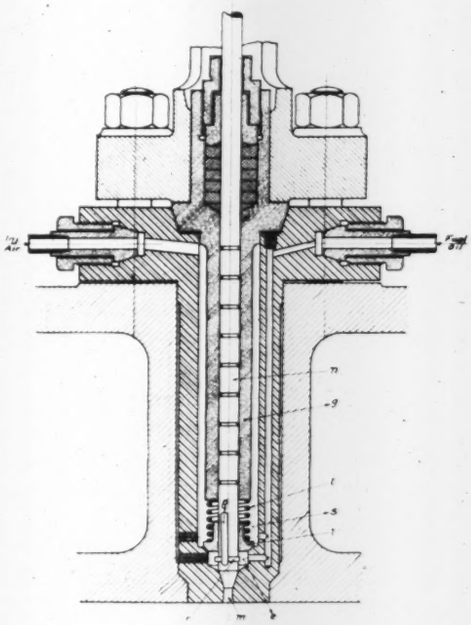


Fig. 12 Typical Fuel Atomizer used on European Diesel Engines

The cross-section through cylinder head shown in Fig. 10 is typical for the valve arrangement and valve gear shown in Fig. 8, but, although quite generally used, it can hardly be considered an ideal one. With the exhaust and admission passages running in different directions and the starting valve placed to one side of center line *B-B*, this cylinder head has no axis of symmetry; the unequal distribution of metal is likely to cause initial strains of widely varying magnitude at different points of the casting which cannot be entirely relieved by annealing. Under this condition, the additional and quite considerable, strains resulting from the high working temperatures and pressures in the engine cylinder may cause deformations (sometimes even rupture) which will seriously affect the life of the valves and impair the accuracy of their timing, particularly the closely fitted injection valves. It is evident that the overhanging lugs *S*, which support the valve gear posts *P* (see Fig. 8) transmit quite an appreciable bending moment upon the walls of the cylinder head, thus adding to the complexity of the case.

Considerably more freedom from all these influences is obtained with a cylinder head as shown in Fig. 11. The symmetrical distribution of the metal about the axis *B-B*, together with liberal hand holes *O*, are conducive to small initial strains and more uniform working strains, aside from offering the advantage of easier moulding. This arrangement is made possible by locating the air starting valve on center line *B-B*, away from the valve gear side. No bending strains are transmitted to this cylinder head since chair *C* (Fig. 9), supporting the valve gear, is mounted on the cylinder head and held down by the two studs *X*.

One of the most important parts of the Diesel engine

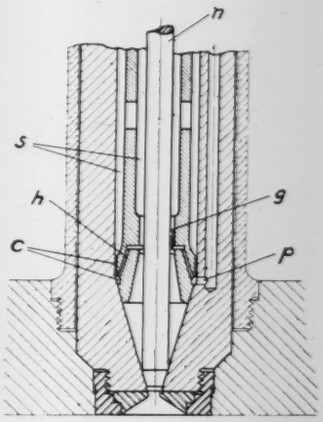


Fig. 13 Another well established form of Atomizer for Vertical Engines

is the fuel injection valve, which, as Fig. 9 shows, is arranged vertically in the center of the cylinder head. This has been found to be the most advantageous location and is one of the reasons why the vertical engine finds so much preference among Diesel engineers. With all the valves arranged vertically in the cylinder head, whereby wear on their guides is almost entirely eliminated and accurate seating at all times insured, a perfectly cylindrical and, therefore, most ideal combustion chamber is obtained. A similar form of combustion chamber can, of course, also be obtained on horizontal engines if the valves are placed horizontally; this, however, means resorting to a practice long ago discarded on gas engines after it was found to be inferior to the vertical valve arrangement.

The introduction of the fuel into the engine cylinder is one of the most intricate problems involved in Diesel engine design. This can be readily understood if it is remembered that on stationary engines of the type here considered, a period of only about $^1/_{25}$ to $^1/_{35}$ of a second is available gradually to inject the fuel, and at

the same time convert it from the liquid state into very minute particles which will have to be gasified and brought into intimate contact with the air necessary to sustain combustion. The usual means for accomplishing this is illustrated in Fig. 12, where the lower end of the needle valve guide *g* is provided with a series of perforated discs *b*, the holes in which straddle each other from plate to plate. Between injection periods the fuel oil is deposited on these discs where it will spread out and equally distribute itself all around the valve guide. When needle valve *n* opens, the high pressure air blast passing down through the holes in plates *b* will wipe the oil off from these comparatively large surfaces and carry it through longitudinal or spiral grooves *p* and nozzle *m* into the combustion chamber; the artificial resistance thus introduced to retard the oil while the air passes over it at a high velocity, effectively disintegrates the liquid into a very fine spray.

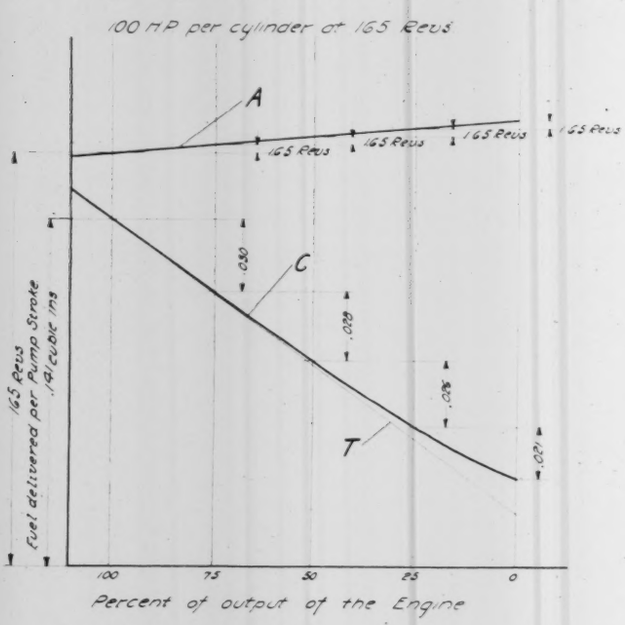


FIG. 14 REGULATION DIAGRAM OF A 100 H.P. DIESEL ENGINE

Quite a number of modifications, all based upon the principle just explained, have lately come into existence for use with various fuels. Notable among these are the provisions made to insure the introduction of fuel into the combustion chamber with the very first particles of injection air, particularly with fuels having a very high flash point. Experience has taught that in connection with such oils the cooling effect of the injection air has a detrimental influence on quick and complete combustion which can only be eliminated with any degree of certainty by providing for immediate ignition of oil particles as soon as the injection valve opens. It is beyond the scope of this paper to attempt to cover this very interesting phase of Diesel engineering, especially since it is still decidedly in the development stage.

For completeness, however, reference will be made to another of the well-established forms of atomizers for vertical engines, the principle of which differs somewhat from the one described above. Oil is delivered through passage *p*, Fig. 13, partly filling annular space *c* as well as a series of holes *h*, while space *s* is as usual in connection with the injection air receiver. With the opening of needle valve *n* the flow of injection air will immediately cause a drop of pressure at *g*, thus gradually forcing the oil up through holes *h* into the stream of injection air passing down along valve *n*. It will be observed that in this atomizer also great care has been taken to insure equal distribution and thorough mixing of oil with the injection air.

While the injection valve provides the means whereby atomization and introduction of fuel into the engine cylinder are controlled, it is the function of the fuel pump to deposit the proper amount of fuel oil in the injection valve cage; upon the former depends the economy of the engine, while the latter affects the regularity of its operation. This is again a phase of Diesel engineering which requires extremely careful study on the part of the designers as the following consideration will show: Fig. 14 represents the regulation diagram of a 100 h.p. engine at a normal speed of 165 r.p.m. Any change of load will cause a change of speed and corresponding change of governor collar position, the ideal condition being where these changes are proportional to the load carried by the engine. This condition is represented by line *A* which, it will be observed, shows equal increments of speed changes and governor collar travels for equal load increments. Curve *C* shows the variation in the amount of oil to be delivered per pump stroke for these various load increments. At the normal load 0.141 cu. in. of oil are required per pump stroke; at three-quarter load this quantity is reduced by 0.030 cu. in., at one-half load by about 0.028 cu. in., etc., down to 0.021 cu. in. at no load. From this it follows that while the governor collar travels are constant for the same fractional load variations the changes in the capacity of the oil pump follow a different law. Considering the fact that the quantities to be pumped are extremely small and must, as we have seen, be delivered against the high pressure of the injection air, the care involved in a pump of suitable design can readily be appreciated.

Mention must here be made of the so-called "open injection nozzle" and its effect upon the pump design, which has lately been greatly exaggerated. The characteristic feature of the open injection nozzle consists of a small chamber or passage continuously in communication with the combustion chamber through the injection nozzle, the fuel oil being delivered into this chamber while the pressure in the engine cylinder is approximately atmospheric. By this expedient no appreciable back pressure has to be overcome by the pump in delivering its charge which, it is claimed, greatly simplifies its construction. It cannot be de-

nied that this is of some advantage inasmuch as a stuffing box on the plunger can be dispensed with. It is extremely questionable, however, whether this slight simplification of the pump compensates, especially in larger engines, for the indirect control of fuel injection with a valve which merely cuts off the injection air blast. To the author's knowledge no success has so far been had with the open nozzle arrangement on vertical engines.

Curve C of Fig. 14 incidentally shows the remarkably steady fuel consumption of the Diesel engine, which is almost proportionate to the engine load as a comparison with tangent T to curve C at the point of normal load indicates. In this respect the Diesel engine differs from any other prime mover known today and accounts for the fact that even at a small load factor its economy is singularly high. Moreover, this economy is maintained in continued operation since the automatic and complete control of the governor and absence of all auxiliaries entirely eliminates the personal element.

Three distinctly different methods of fuel oil pump regulation are known today:

1—Variable stroke of the pump plunger;

2—A mechanically operated by-pass valve by means of which more or less of the oil taken in during the suction stroke is returned to the suction chamber during the discharge stroke; and

3—Variation of the capacity of the pump chamber (variation of the clearance volume).

Typical forms of oil pumps constructed on the first method are shown diagrammatically in Figs. 15 to 18. In Fig. 15 the pump plunger is operated positively on the discharge stroke by means of a cam while on the return or suction stroke a spring keeps the plunger in contact with the receding cam until it is stopped by a governor-operated wedge which thus varies the suction stroke. This form of pump is unsuitable for work against heavy pressures as the friction of the plunger stuffing box could only be overcome by quite a heavy spring which from the time the plunger is forced against the wedge, would render the governor inoperative; on light loads this would happen during almost the complete turn of the cam so that regulation would be seriously affected. The same holds true of the pump shown in Fig. 16, where a shaft governor acts directly upon two eccentrics to shift one relative to the other and thereby change the stroke of the plunger. With a stuffing box sufficiently tight to pack the plunger against heavy pressures, as well as due to the pressures acting upon the plunger itself, the reaction upon the governor would frustrate all attempts of regulation. Both these forms of pumps are, therefore, only used in connection with open nozzle engines where low back pressure on the oil permits the elimination of a gland at the plunger.

Fig. 17 illustrates an attempt at adapting the variable stroke principle for high-pressure work; here the plunger is operated indirectly from a cam by means of a lever and a bell crank with a governor controlled roller interposed between them. As in Fig. 15, the discharge stroke only is positive, the return stroke

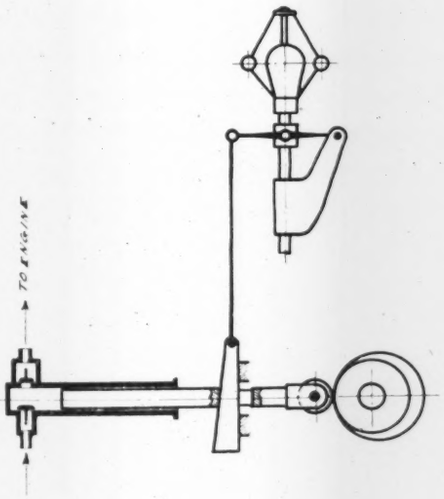


Fig. 15 Method of Governing by Controlling Length of Suction Stroke

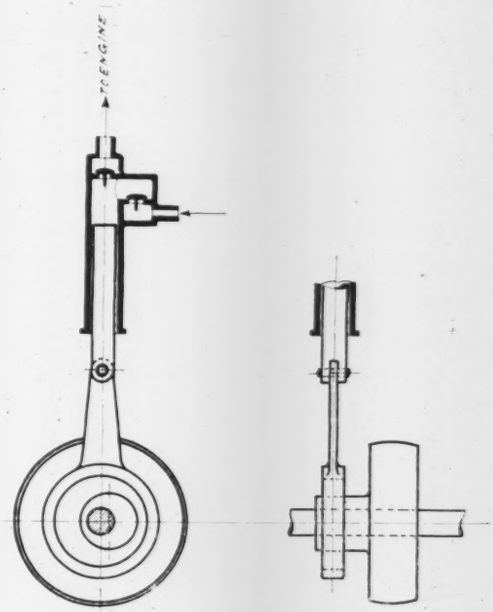


Fig. 16 Governing by another Method of Changing Length of Suction Stroke

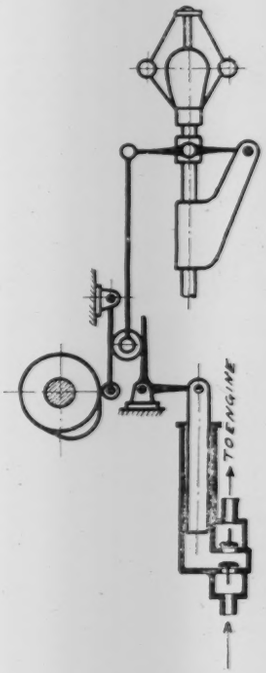


Fig. 17 A Lever and Bell Crank Mechanism for Changing Stroke

again being accomplished by means of a spring which in this case must be heavy enough to overcome the gland friction at the plunger. It is evident that in spite of the roller, excessive friction work can be easily imposed upon the governor if the gland at the plunger or the spring for actuating it is carelessly adjusted, and this form of pump, therefore, can hardly be considered satisfactory in all respects for accurate regulation.

Fig. 18 illustrates the very interesting case where the process of measuring the oil and then forcing the measured quantity to the engine against the high pressure of the injection air is assigned to two separate plungers. The forcing plunger p is positively operated from an eccentric or crank at constant stroke while the measuring plunger m derives its movement from the former through a system of levers. Regulation is obtained by means of bell crank c which permits the governor to shift the fulcrum of lever a. With this arrangement the measuring is accomplished under the moderate pressure head at which the oil usually flows to the pump, and a gland at the measuring pump plunger can be dispensed with, thus reducing friction to a minimum so that practically no reaction should manifest itself at the governor. The above-mentioned disadvantages of the variable stroke plunger arrangement for heavy work have thereby been overcome, although the rather complicated mechanical structure requires careful design and workmanship in order to prevent excessive wear at its many links and pins.

Two typical forms of pumps of the second method are illustrated in Figs. 19 and 20, their characteristic feature being the plunger positively operated by an eccentric crank having a displacement considerably larger than the maximum charge of fuel oil required by the engine. Regulation is obtained by the governor acting upon the suction valve through a system of levers in such a manner that during the first part of the discharge stroke this valve remains open for a longer or shorter period; after a certain amount of oil has thus been by-passed to the suction chamber the valve returns to its seat and during the remainder of the stroke oil is forced to the engine. With the exception of slight modifications in details of construction, Figs. 19 and 20 are representative of the most generally used method of regulation on Continental Diesel engines; one and the same pump lends itself readily to a wide variety of engine sizes by simply varying the point of closing of the suction valve. But the present patent situation in the United States will undoubtedly greatly restrict the use of such pumps for some time to come.

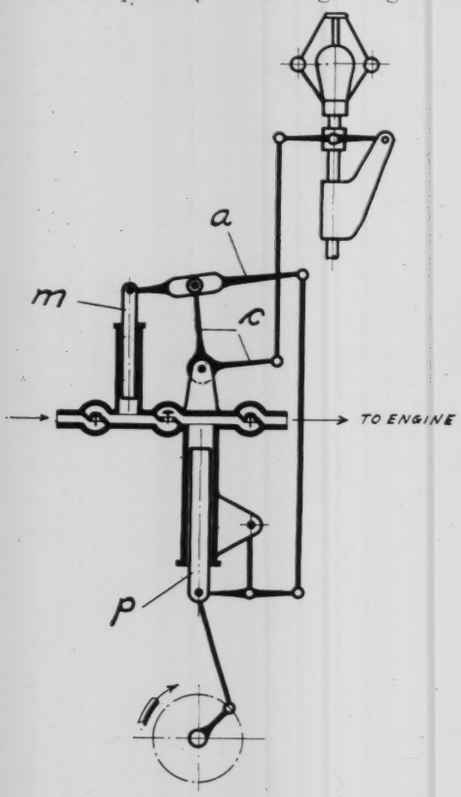


Fig. 18 Governing the use of two Pumps, one for Measuring and the other for Forcing

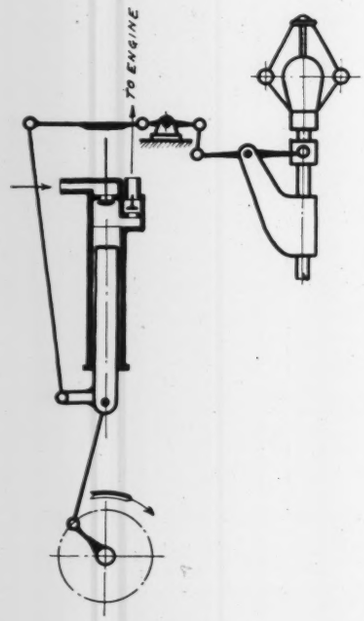


Fig. 19 Method of Governing by By-passing to Suction Chamber

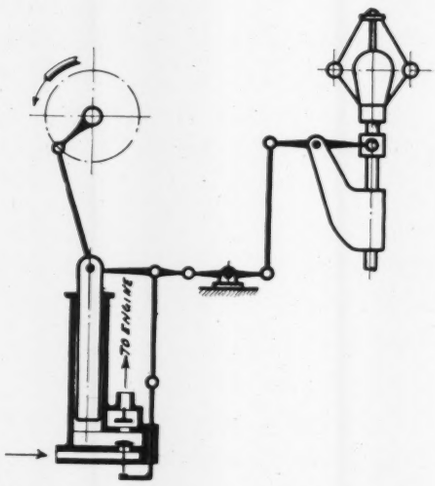


Fig. 20 Another form of Governing by By-passing to Suction Chamber

Fig. 21 shows a pump of the third method, where the capacity of the pump chamber is varied independently of the pump plunger. The latter is again positively driven and has, therefore, a constant stroke and displacement. One end of the pump chamber is formed by a diaphragm which is secured at its outer

periphery so that it lies normally flat as shown. At the beginning of the discharge stroke the pressure exerted upon the oil in the pump chamber causes the diaphragm to deflect until it lies against the unyieldable stop *m*, and the remainder of the oil is then forced to the engine. On the next suction stroke the diaphragm returns to its flat position and a new supply of oil is taken in through the suction valve *s*, the amount of oil enclosed in the pump chamber at the beginning of each discharge stroke being, therefore, always the same. Regulation is obtained by changing the position of stop *m* by means of wedge *a*, which is connected to the governor and against which the stem of stop *m* rests. It will be noticed that this pump regulates by changing its clearance space, in which a variable quantity of oil can be stored while the remainder goes to the engine.

The longitudinal and cross-sectional views, Fig. 22, give an idea of the constructional details of a pump of this principle. It is provided with two diaphragms, one on each side, and the stops which limit the deflection of the diaphragms are made up of a series of segments, *S*, supported at their outer periphery on the covers *C*, while their inner ends engage with the regulating screws *R*. The latter are acted upon by the governor through levers L_1 and L_2, which turn these screws over a larger or smaller angle according to the change in the position of the governor collar, and segments *S* are accordingly tilted from their straight position thus permitting the diaphragms to deflect more or less. The pitch of screws *S* is determined in such a way that, for a given maximum governor collar travel, the corresponding deflection of the diaphragms will always be within a very safe limit, never amounting to more than $\frac{1}{32}$ in. In other words, their maximum deflection corresponds to a load which is only a very small fraction of the pressure against which the oil is forced to the engine. Since these diaphragms are in any position supported over their whole surface by unyieldable rigid supports, it is the latter that carry the full load, leaving the diaphragms unaffected. A part of the load thus carried by the segments, *S*, will be transmitted to the regulating screws which might be expected to produce sufficient frictional resistance to temporarily render the governor inoperative, but in actual practice it was found that this resistance is either not sufficient or else the time during which it manifests itself too short to lock completely the governor. It has, however, a beneficial dampening effect, similar to a dash-pot, which effectively prevents oscillations, for instance, during rapid changes of load, and the essential requirements for close regulation are thus met with extremely simple means.

This pump has only one plunger, and for multi-cylinder engines provisions must therefore be made to distribute the oil equally to the various cylinders. A so-called distributor, *B*, which in Fig. 22 is shown for a three-cylinder engine, is used for this purpose. Since there is usually a considerable difference in the distance and, therefore, resistance of the oil pipes between the fuel pump and the various engine cylinders, means must be provided whereby these resistances can be equalized, and this is accomplished by means of calibrated orifices *O* which may be throttled more or less with the needle valves *N*. With this arrangement sufficiently close adjustments can be made to obtain indicator cards in the various engine cylinders which do not differ more than 2 to 3 per cent from one another, and it is still an open question whether or not these slight discrepancies, which might from other sources become considerably larger, warrant the use of a separate pump for each cylinder; the greater complication and expense of this latter expedient seem hardly warranted for small and medium size engines.

There are a number of details which, although known from gas engine practice, have had to undergo

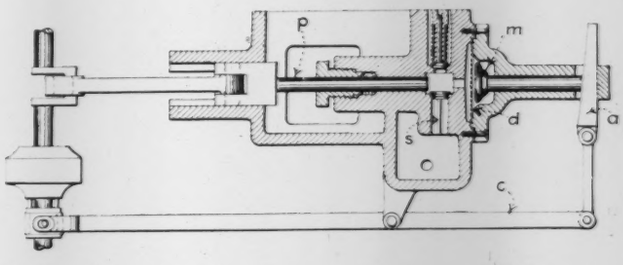


Fig. 21 Method of Governing by Variation of Capacity of Pump Chamber

a distinct development of their own in order to meet Diesel engine requirements, but instead of discussing them, I wish to point out a few general features of an American-built Diesel engine. Fig. 23 illustrates the Fulton-Tosi oil engine, which in its general appearance resembles the typical moderate-speed Diesel engine as it is built to-day by the leading European manufacturers. The main engine structure consists of an individual A-frame for each cylinder, mounted on a shallow base plate of box section. The main bearings as well as the crank and piston pin boxes are designed in accordance with the considerations laid down in the early part of this paper. This method of journaling the moving parts, together with the individual A-frames with their central load transmission and resulting freedom from uncontrollable strains, insure maximum rigidity and, therefore, maintenance of accurate fits and alignments. The upper part of these A-frames forms the cylinder jacket into which the cylinder proper is inserted in the form of a liner, held at the top by means of the cylinder head and free to expand longitudinally. Owing to the uniform cooling which insures the maintenance of a true cylindrical liner the piston can be made exceptionally long, thus reducing the unit side pressure due to the connecting

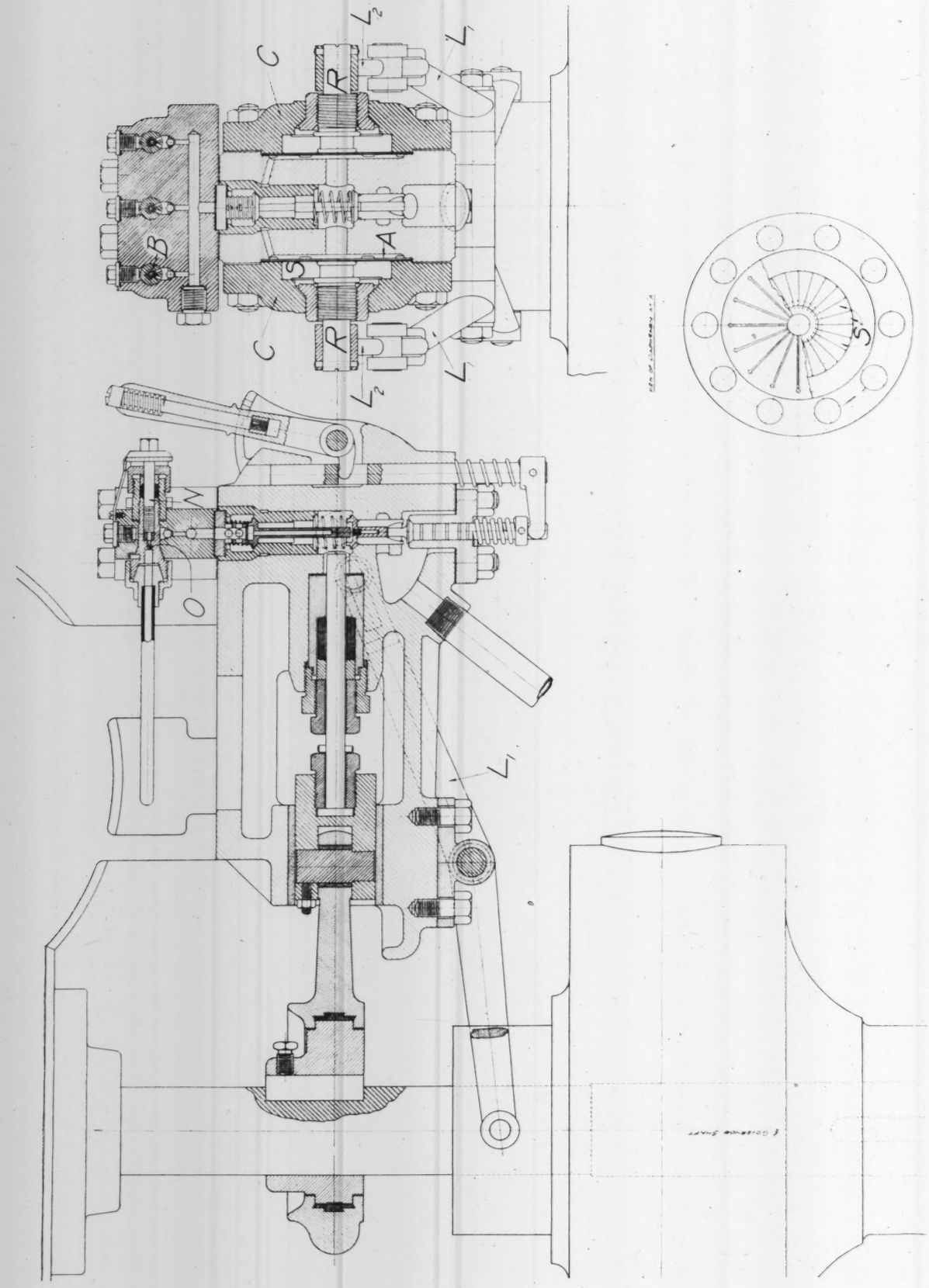


Fig. 22 Constructional Details of a Fuel Injection Pump designed to Govern by Variation of Capacity of the Pump Chamber

rod thrust to a figure which insures minimum wear. The nicety with which this very important requirement can be met on vertical engines is another reason for their unsurpassed success; it is today not at all unusual to find such engines in which the pistons, after five and more years of hard service, are still fitting their cylinders perfectly. Fig. 23 shows one of these engines of 150 h.p. on the testing floor.

After all these foregoing considerations have been duly taken into account, it is proper to state that another most important requirement is an equipment in the machine-shop that will enable the observation of painstaking accuracy and fits which on many parts must not vary more than a few ten-thousandths of an inch. In the early history of its commercial development it occurred several times that leading concerns could not "make a go" of the Diesel engine, although they had used designs which had proven their success where first brought into existence, and as a consequence the manufacture was repeatedly dropped as unprofitable only to be taken up again later on. In the

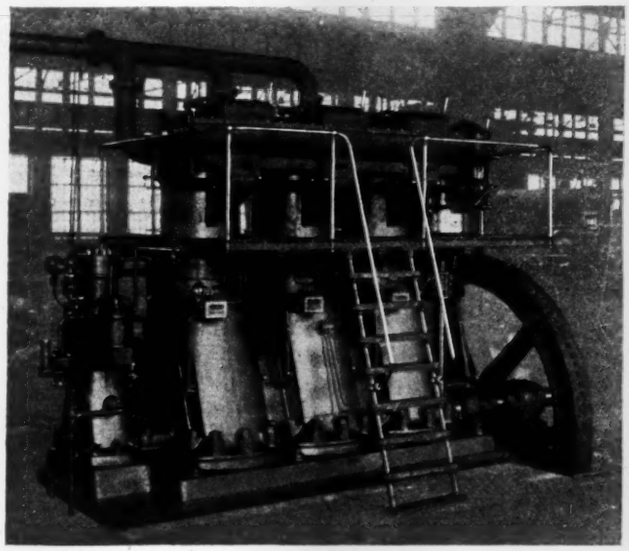


Fig. 23 View of a 150 H. P. Fulton-Tosi Diesel Oil Engine on the Testing Floor

meantime it had been proven that it was mostly lack of appreciation of the accuracy of workmanship required that had caused these early negative results. Both the tools and the measuring facilities were generally inadequate, especially the latter, the limit system of measurements being at that time very little understood; accurate work and proper fits depended in a great many shops entirely on the experience of the machinist who usually had to make all those parts that went together. Fortunately the advantages of interchangeability in the manufacture of machinery have been early recognized here and at least the leading American shops should today be able to approach the manufacture of Diesel engines with a clear understanding of the essential methods to be followed.

It is hardly necessary to emphasize the fact that a considerable amount of preparatory work, both in the form of effort and capital, is involved before the manufacture of Diesel engines can be carried out on a commercial basis, which alone will make it possible to realize any returns from the enterprise. The immediate question then is will the commercial possibilities warrant such an investment, and to answer this, we must first compare the Diesel engine with the other existing forms of prime movers. A good idea as to their relative economies may be had from Fig. 26, which is based upon representative test results on engines ranging from about 150 b.h.p. to about 600 b.h.p. capacity. Non-condensing steam engines, for instance, show a heat

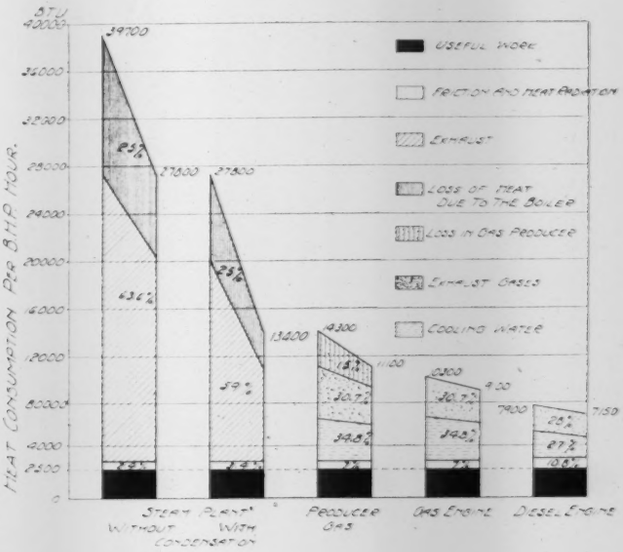


Fig. 24 Diagram showing Relative Economies of Steam Engines, Gas Engines and Diesel Engines

consumption per b.h.p. varying from 39,700 B.t.u. on the smaller sizes down to about 27,800 B.t.u. on larger units. These test results are, however, seldom if ever realized in actual practice, by far the large majority of steam plants, both condensing and non-condensing, as well as the producer plants, showing considerably higher consumptions under actual running conditions. While this applies to a lesser degree even to gas engines, this influence is entirely eliminated in the Diesel engine, and it is a matter of common knowledge today that its superior economy is maintained practically unimpaired in continued operation. If to this is added the fact that these engines require considerably less labor than either a steam or producer plant, it becomes apparent at once, that for the same operating conditions, both the first cost of the Diesel plant itself and the cost of the fuel used therein may be considerably higher than the corresponding figures for a steam and even producer plant of the same size. Just how much these differences may be depends, of course, on local conditions, such as cost of fuel, load factor, utilization of exhaust heat, etc.

This much is certain, however, that with very few exclusive cases, the Diesel engine is the coming prime mover for the whole South and Southwest. This vast section of the United States enjoys the advantage of having tremendous oil fields in such close proximity that an abundance of liquid fuels are available at a cost which compares favorably with that of coal. Based upon prices prevailing today, the cost of 1,000,000 B.t.u. bought in the form of liquid fuel ranges from 15 to 20 cents, while in the case of coal the corresponding figures will vary from 15 to 23 cents. From a monetary standpoint the two fuels are, therefore, approximately on a par, this proving that under present conditions the cost of one is regulated by that of the other.

In this connection it is interesting to note that in Germany, where during the last six years Diesel engines to an aggregate horse-power of over 500,000 have been built and installed, the cost of 1,000,000 B.t.u. bought in the form of gas or fuel oil ranges from 59 to 89 cents, as compared to from 12 to 26 cents in the form of coal. While the smaller Diesel engines can today still be operated economically under such adverse conditions, a cheaper fuel in the form of tar oil is resorted to in the case of larger installations, which makes it possible to obtain 1,000,000 B.t.u. at a cost of from 27 to 40 cents, which is still considerably higher than coal. Nevertheless, the Diesel engine, by virtue of its superior economy, easily meets the competition of the steam power plants, except in very large units, or such cases, of course, where the exhaust steam can be profitably utilized for heating purposes. This is all the more significant in view of the fact that even comparatively small German steam plants are equipped with superheaters and operated under high pressures, which materially reduces the coal consumption as compared to the average American steam plant of the same capacity.

This comparison furthermore brings out the fact that conditions for the operation of Diesel engines are far less favorable in Germany, where this type of prime mover is today holding almost uncontested sway, than in even less advantageous sections of the United States than the South and Southwest. The hundreds of oil-fired steam plants in this latter part of the country are bound to rapidly disappear. Present economical conditions imperatively demand conservation of national wealth, be that in the form of natural resources or human efforts. That the Diesel engine means a tremendous factor in this problem of economics could not be better expressed than by the fact that it enables the production of a barrel of flour at from $1\frac{1}{2}$ to $1\frac{3}{4}$ cents for fuel oil, compared to 8 and 10 cents, and even more, for steam; or the pumping of water at from 7 to 9 gal. of fuel oil per 100 water horse-power against 50 to 60 gal. for steam plants. Similar remarkable results are obtainable in the operation of ice and electric power plants.

Provided due consideration is given by the manufacturers and engineers to the particular problems involved in the construction of this prime mover, and the matter is earnestly studied along such lines as laid down in the foregoing, American engineers will soon learn to discriminate between reliable and questionable features of design and construction. Moreover, they will begin to realize that price is not the first consideration in the purchase of oil engines; the lower cost of an engine which is inferior in regard to details of construction can never compensate for the resulting shut-downs and repairs. This is a point of far more than individual importance, since the failure of one installation due to cheap and unsuitable design will seldom be traced to its source. Much more frequently the opposite occurs and the whole class of similar prime movers is condemned. It would be deplorable if many such cases should have to be recorded after the Diesel engine has made such remarkable progress in other countries, since the public at large would thereby be deprived of one of the most remarkable products of modern technical development.

CLASSIFICATION AND HEATING VALUE OF AMERICAN COALS

BY WILLIAM KENT, NEW YORK CITY

Member of the Society

THE recent publication by the United States Bureau of Mines in Bulletin No. 22 of over 3000 analyses and results of calorimetric examinations of American coals offers the best opportunity that has ever been had for a study of the long-mooted questions of the classifications of coals and of the relation of their chemical composition to their heating value.

The writer has made an attempt at such a study and gives the principal results of it herewith, although they are by no means complete. It was not possible in the limited time at his disposal to take all the analyses of heating values and compare them, but instead he has made a selection of 155 analyses of coals from different states, showing practically the extreme range of composition of heating value of the coals of each of these states, whenever a sufficient number of coals of such states are given in the bulletin. The most important items of the ultimate and proximate analyses were tabulated, viz., the S, H, C, O, and N of the ultimate analysis as referred to the combustible (coal free of moisture and ash), also the volatile matter, the moisture and the ash of the proximate analysis, the moisture and ash being referred to the coal as received, and the volatile matter being referred to the combustible.[1] The fixed carbon was omitted in order to save space. Referred to combustible it is 100 per cent minus the volatile matter of the combustible, and referred to coal as received it is 100 per cent minus the sum of moisture ash and volatile matter.

The actual analyses, both proximate and ultimate, were made on air-dried coal, the surface moisture having been first removed. The results as given in the bulletin are calculated to three different bases: (1) as received, (2) dry coal, (3) ash and moisture free (commonly called combustible); and in many cases to a fourth basis, ash, moisture and sulphur-free. For the purpose of comparison, however, other information was desired, such as the B.t.u. per lb. of coal air-dry, ash-free, and air-dry, ash and sulphur-free, not contained in the bulletin. The writer has calculated and tabulated these omitted items, but it should be stated that the figures which he obtained relating to B.t.u. calculated to the sulphur-free basis, are probably too high in many cases of high sulphur coals, as will be shown later.

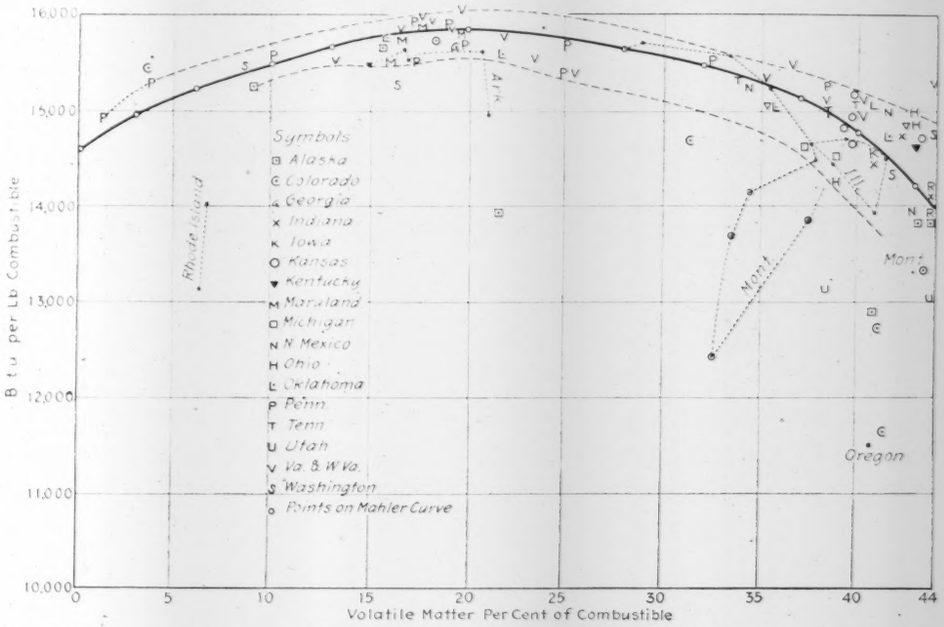


FIG. 1 RELATION OF HEATING VALUE TO PERCENTAGE OF VOLATILE MATTER IN THE COMBUSTIBLE

Having thus tabulated the results, the questions to be solved are (1) how shall the coals be classified; (2) what relation does the heating value of the coals bear to the chemical composition.

The earliest published classification of American coals is that of Persifor Frazer, Jr., in 1874 (Trans.

[1] See Table 1.

Presented at the Spring Meeting, at St. Paul-Minneapolis, 1914, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

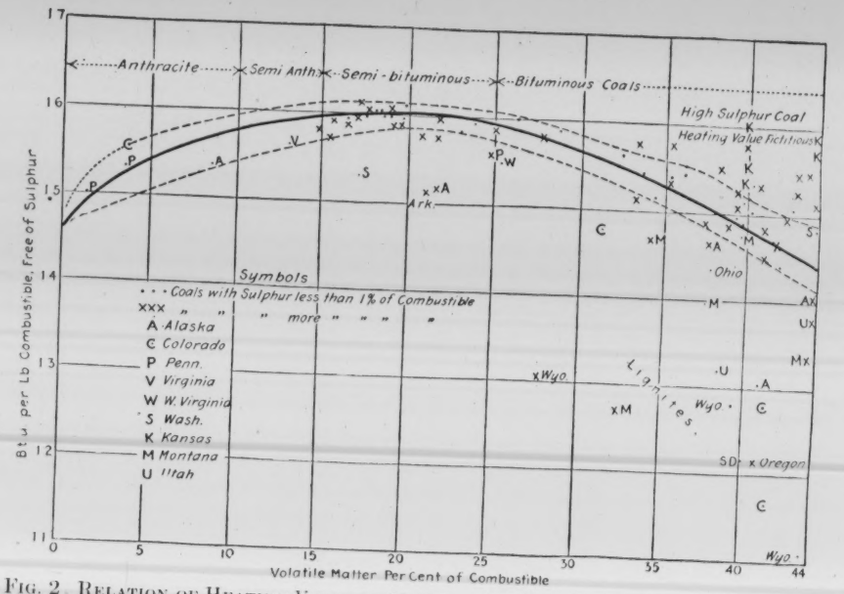


FIG. 2 RELATION OF HEATING VALUE TO VOLATILE MATTER IN COMBUSTIBLE FREE OF SULPHUR

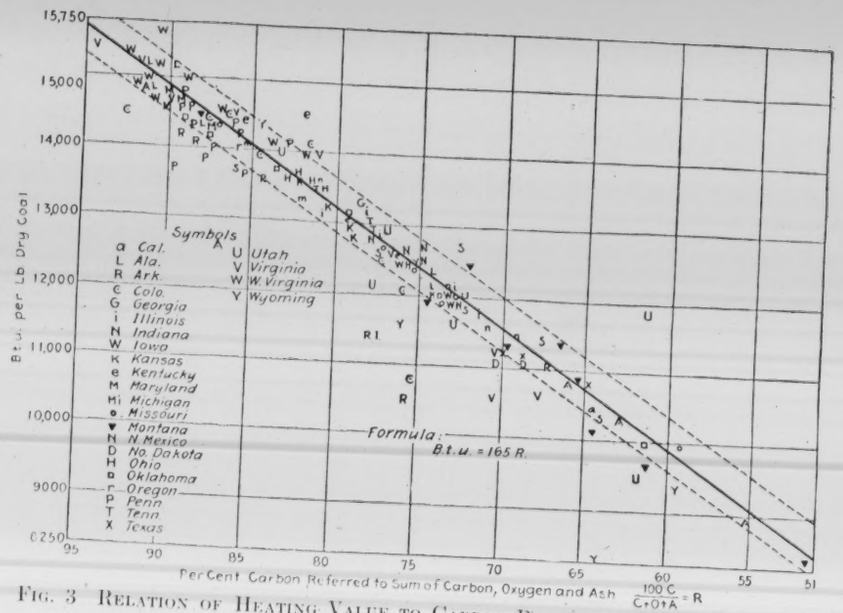


FIG. 3 RELATION OF HEATING VALUE TO CARBON REFERRED TO SUM OF CARBON, OXYGEN AND ASH

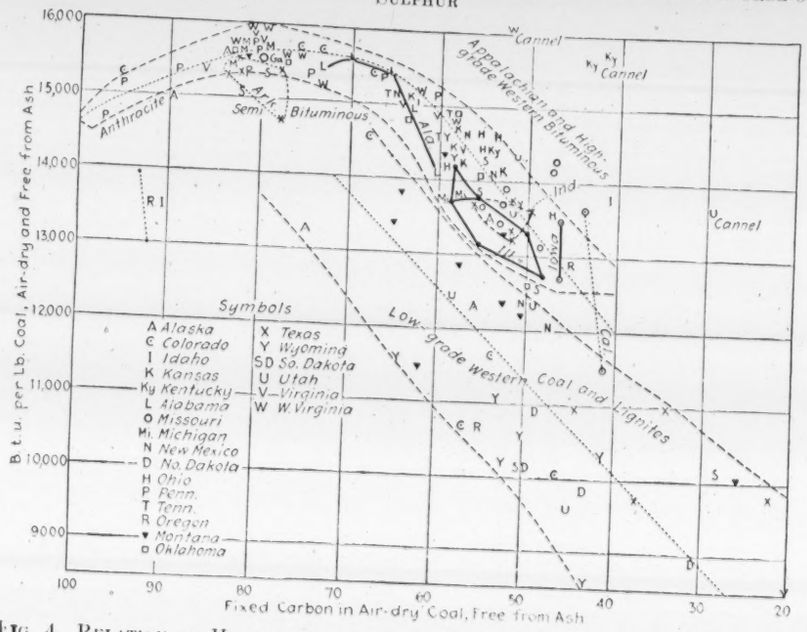


FIG. 4 RELATION OF HEATING VALUE TO FIXED CARBON IN AIR-DRY COAL, FREE FROM ASH

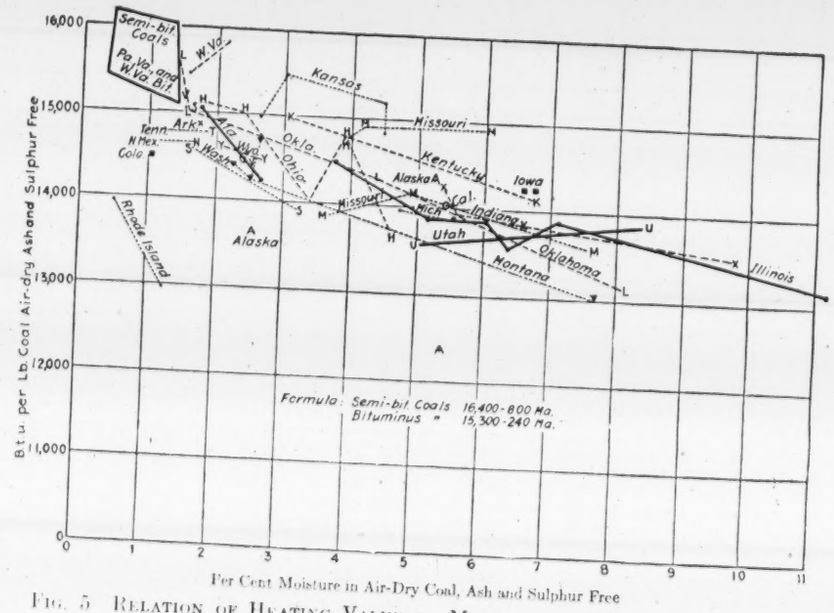


FIG. 5 RELATION OF HEATING VALUE TO MOISTURE IN AIR-DRY COAL, ASH AND SULPHUR FREE

TABLE 1 CLASSIFICATION OF COALS

		Volatile Matter Per Cent of Combustible	Oxygen in Combustible Per Cent	Moisture in Air Dry Coal Free from Ash Per Cent	B.t.u per Lb. Combustible	B.t.u. per Lb. Coal Air Dry Ash Free
I	Anthracite	less than 10	1 to 4	less than 1.8	14,800 to 15,400	14,600 to 15,400
II	Semi-anthracite	10 to 15	1 to 5	less than 1.8	15,400 to 15,500	15,200 to 15,500
III	Semi-bituminous	15 to 30	1 to 6	less than 1.8	15,400 to 16,050	15,300 to 16,000
IV	Cannel*	45 to 60	5 to 8	less than 1.8	15,700 to 16,200	15,500 to 16,050
V	Bituminous, high grade	30 to 45	5 to 14	1 to 4	14,800 to 15,600	14,350 to 15,500
VI	Bituminous, medium grade	32 to 50	6 to 14	2.5 to 6.5	13,800 to 15,100	13,400 to 14,400
VII	Bituminous, low grade	32 to 50	7 to 14	5 to 12	12,400 to 14,600	11,300 to 13,400
VIII	Sub-bituminous and lignite	27 to 60	10 to 33	7 to 26	9,600 to 13,250	7,400 to 11,650

* Eastern cannel. The Utah cannel is much lower in heating value.

A.I.M.E.). He divided the coals into anthracite, semi-anthracite, semi-bituminous and bituminous, and he used what he called the "fuel-ratio" or the ratio of fixed carbon to the volatile matter in the combustible, as the basis of subdivision between the several classes. The names he used are still retained, although the figures of fuel-ratio which he gave are no longer accepted as marking the divisions into classes, but the bituminous coals have been divided into two or more classes, as bituminous and lignite, and the lignites have been recently subdivided by the U. S. Geological Survey and the Bureau of Mines into sub-bituminous and lignite.

Frazer's method of using the ratio of one constituent to another, or of one to the sum of two others, has been followed by several writers, such as David White,[2] who uses the ratio $\frac{C}{O+A}$ in which C, O and A are respectively the carbon, oxygen and ash in the dry coal. The expression of the relation of two elements as a ratio is not as convenient for the purpose in view as the expression of the same relation as a percentage, or the ratio of one of the two elements to the sum of the two. Thus by Frazer's method two coals having fuel ratios differing as widely as $\frac{97}{3} = 32.3$ and $\frac{92}{8} = 11.5$ are both anthracites, the first having 3 per cent and the second 8 per cent of volatile matter in the combustible, while two other coals, also differing 5 per cent, viz., one with 48 and the other 53 per cent of volatile matter in the combustible, have fuel ratios that differ but little, or $\frac{52}{48} = 1.08$ and $\frac{47}{53} = 0.90$. Mr. White plots the B.t.u. per lb. dry coal as ordinates and the ratio $\frac{C}{O+A}$ as abscissae, and obtains a curve that begins in a nearly vertical direction, where with coal very high in oxygen and ash the ratio is less than 1, and ends in a direction that is nearly horizontal, becoming actually horizontal when $\frac{C}{O+A} = 0$ and the ratio becomes infinity, while if he had plotted the B.t.u. against the ratio $\frac{C}{C+O+A}$, which may be expressed as a percentage, the curve would have become an inclined straight line.

In 1892 the writer published in Mineral Industry the results of a study of Mahler's researches on European coals, in which by means of plotting the B.t.u. against the percentage of fixed carbon in the combustible and drawing a curve through the plotted points, he showed that the B.t.u. per pound of combustible of the coal tested by Mahler was related to the percentage of volatile matter in the combustible. Messrs. Lord and Haas published later the results of their tests of Pennsylvania, Virginia, and Ohio coals and stated that they had found no such relation, but on the contrary that the combustible portion of coals of certain districts had remarkably uniform heating values, which were independent of the percentage of volatile matter. In a discussion of Lord and Haas's paper[3] the writer plotted their results and compared them with the curve derived from Mahler's tests, and showed that the Pocahontas coals fell on the Mahler curve, and that the tests of Pennsylvania and Ohio coals having about 45 per cent of volatile matter fell within the Mahler field, showing a variation of 3 or 4 per cent as maximum from the curve, but that as Lord and Haas said, each coal district had a law of its own, and that two Ohio coals from different districts in the same state each with the same percentage of volatile matter in the combustible might vary 6 or 8 per cent in heating value per pound of combustible.

In studying the 155 coals, the writer first plotted the B.t.u. per lb. combustible with the results which are shown graphically in Fig. 1. This plotting shows that all the coals of the Appalachian field come close to the original curve drawn from Mahler's tests of European coals, when the volatile matter in the combustible is 35 per cent or less. For coals higher in volatile matter, and for Western coals generally, the heating value varies over a wide range and appears to have no relation to the volatile matter, but each district has a law

[2] U. S. Geol. Survey, Bulletin 382, 1909. The Effect of Oxygen in Coal. David White.

[3] Trans. A. I. M. E., Vol. 27, p. 946.

of its own. The Illinois coals are all found within the small area shown by dotted lines. Perhaps the most important conclusion from Fig. 1 is that all the semi-bituminous coals of the Eastern States, and those from the Western States and Alaska, with a very few exceptions, have a heating value per pound of combustible that is very close to 15,750 B.t.u. With bituminous coals and lignite containing over 36 per cent of volatile matter in the combustible there appears to be no law connecting the heating value with the percentage of volatile matter, and the plotting is not continued beyond 44 per cent.

As many of the coals high in volatile matter are also high in sulphur, it was attempted to find if high sulphur was the cause of some of the variation of the heating value, but the results are negative. When the heating value per pound of combustible is converted for sulphur by the usual method, by subtracting 4050

TABLE 2 CLASSIFIED LIST OF COALS

	Order in Table 1	Combustible				Air-dry Ash-free		B.t.u. Greater (+) or Less (−) than Estimated by				
								Combustible		Air-dry Ash-free		Dry Coal
		Vol.	S.	O.	B.t.u.	Moist	B.t.u.	Dulong Formula	Mahler Curve	F. C. Curve	Moisture Formula	C / C+O+4
I. Anthracite												
Alaska	4	8.8	0.73	4.04	15,203	1.55	14,968	− 50	− 76	− 263	+ 87	− 172
Colo	5	3.6	0.87	1.32	15,413	1.08	15,247	− 164	+ 373	+ 305	− 183	− 756
Pa	7	1.3	1.00	2.13	14,882	1.43	14,666	+ 127	+ 172	− 243	.....	−1102
Pa	8	3.7	0.68	2.41	15,248	0.83	15,123	− 75	+ 208	+ 193	.....	− 693
Wash	5	8.5	0.72	2.67	15,410	0.80	15,367	− 6	+ 20	+ 93	− 385	− 453
II. Semi-Anthracite												
Ark	1	14.8	2.33	2.57	15,496	1.45	15,272	− 21	− 176	− 61	.....	− 386
Pa	11	10.0	0.74	2.17	15,457	0.91	15,398	− 193	− 23	+ 15	− 274	− 457
Va	3	13.1	0.82	4.18	15,500	0.90	15,439	− 46	− 160	− 95	− 233	− 58
III. Semi-Bituminous												
Ala	1	28.8	0.59	4.45	15,757	1.15	15,577	− 65	+ 137	− 15	+ 165	+ 99
Ala	2	27.9	1.58	3.42	15,620	0.94	15,475	− 309	− 40	− 147	+ 23	− 176
Alaska	3	15.5	1.29	3.02	15,651	0.60	15,559	+ 13	− 109	+ 9	− 208	− 236
Ark	2	16.7	3.16	1.69	15,624	0.86	15,525	− 176	− 386	− 61	− 21	− 386
Ark	5	17.0	3.57	1.25	15,530	0.92	15,387	+ 1	− 270	− 213	+ 216	− 531
Ark	6	20.7	1.47	4.27	15,602	1.34	15,393	+ 225	− 238	− 288	+ 249	+ 23
Colo	7	23.8	0.58	4.34	15,849	0.83	15,716	+ 195	+ 49	+ 20	+ 55	+ 212
Colo	8	25.8	0.72	2.29	15,939	1.43	15,712	− 295	+ 199	+ 80	+ 443	− 22
Ga	1	19.4	1.55	5.96	15,653	0.74	15,540	+ 487	− 177	− 110	− 87	+ 345
Md	1	16.5	1.13	2.81	15,710	0.90	15,577	− 81	− 90	− 6	+ 36	− 147
Md	2	16.0	1.02	2.54	15,640	1.10	15,478	− 189	− 140	− 102	+ 72	− 284
Md	3	19.7	0.94	3.01	15,826	0.80	15,699	− 65	− 14	− 41	+ 163	− 53
Md	4	17.5	0.98	2.47	15,856	0.66	15,746	− 61	+ 30	+ 145	+ 28	− 100
Mont	9	18.3	0.96	2.93	15,721	0.61	15,625	+ 49	− 99	+ 1	− 170	− 149
Okla	2	21.7	1.15	2.87	15,586	0.53	15,504	− 2	− 244	− 176	− 339	− 260
Okla	3	15.7	1.36	1.87	15,728	0.70	15,619	− 287	− 52	+ 63	− 56	− 287
Pa	2	19.0	1.87	3.32	15,840	0.99	15,680	+ 85	+ 10	+ 38	+ 300	+ 34
Pa	3	24.8	1.81	5.50	15,376	0.40	15,316	+ 110	− 394	− 373	− 557	− 28
Pa	4	25.0	1.50	3.72	15,660	0.86	15,523	− 203	− 110	− 160	+ 20	− 81
Pa	6	19.5	1.73	1.99	15,683	1.50	15,624	− 411	− 157	− 22	+ 643	− 308
Pa	9	17.3	1.63	2.82	15,847	0.65	15,744	+ 149	+ 47	+ 140	+ 65	− 59
Pa	10	17.2	5.09	1.66	15,493	0.76	15,378	− 95	− 307	− 226	+ 217	− 454
Va	4	19.0	0.68	3.42	15,840	0.54	15,750	+ 9	+ 10	+ 110	− 131	0
Va	5	17.5	0.68	2.23	15,910	0.64	15,795	− 236	+ 100	+ 157	− 6	− 179
Wash	6	16.3	0.48	3.97	15,264	1.67	15,013	− 209	− 516	− 588	+ 14	− 251
W. Va	2	25.3	0.86	4.13	15,399	1.18	15,218	− 370	− 371	− 458	− 314	− 306
W. Va	3	23.3	0.61	1.68	15,736	0.90	15,597	− 674	− 84	− 103	+ 55	− 348
W. Va	4	21.8	1.27	5.52	15,781	0.81	15,655	+ 546	− 49	− 29	+ 59	+ 304
W. Va	7	19.9	0.60	2.80	16,038	0.69	15,998	+ 178	+ 208	+ 270	+ 166	+ 95
W. Va	8	16.5	0.79	4.56	15,820	0.65	15,804	+ 255	+ 40	+ 134	− 68	+ 168
W. Va	10	18.1	0.86	1.97	15,919	0.73	15,802	− 145	+ 99	+ 178	+ 100	+ 149
IV. Cannel												
Ky	2	55.5	1.38	7.57	15,800	0.92	15,646	− 153	.....	+3046	+ 198	+ 771
Ky	3	57.0	1.15	7.61	16,013	1.44	15,784	− 91	.....	+3439	+ 686	+ 967
W. Va	1	47.4	0.92	5.34	16,176	0.84	16,042	− 284	.....	+2212	+ 433	+ 674
Utah	6	67.6	2.32	13.68	14,918	8.26	13,686	+ 172	.....	+4974	+ 618	+1683

H in combustible: Ky. 2, 7.13; Ky. 3, 7.46; W. Va. 1, 7.13; Utah, 6, 7.73. The highest H. in the other coals is 5.78, Mo. 6.

TABLE 2 CLASSIFIED LIST OF COALS

	Order in Table 1	Combustible				Air-dry		B.t.u. Greater (+) or Less (−) than Estimated by				
						Ash-free		Combustible		Air-dry Ash-free		Dry Coal
		Vol.	S	O.	B.t.u.	Moist	B.t.u.	Dulong Formula	Mahler Curve	F. C. Curve	Moisture Formula	$\frac{C}{C+O+A}$
V. Bituminous, High-Grade												
Ala	3	33.4	1.13	6.99	15,590	1.23	15,400	+ 564	+ 170	− 24	+ 120	+ 361
Ala	4	35.3	1.07	7.00	15,214	1.77	14,947	− 50	− 76	− 263	+ 87	− 172
Colo	4	31.3	0.72	9.38	14,681	1.01	14,533	+ 1	− 849	− 967	− 447	− 46
Colo	6	33.7	0.56	8.77	15,559	0.87	15,423	+ 489	+ 189	+ 54	− 186	+ 633
Ill	6	40.0	2.82	9.74	14,818	2.34	14,470	+ 434	+ 58	− 30	+ 268	+ 224
Kan	2	39.8	6.68	5.26	15,167	2.86	14,734	+ 69	+ 22	+ 24	+ 908	− 54
Kan	4	39.5	4.93	7.27	14,809	2.49	14,436	+ 28	+ 38	− 234	+ 395	+ 6
Ky	4	35.3	0.58	8.05	15,328	1.64	15,095	+ 255	+ 38	− 131	− 9	+ 313
N. Mex	1	41.5	0.74	8.79	14,875	1.64	14,630	− 145	+ 375	+ 40	.....	+ 138
N. Mex	2	34.4	0.96	6.93	15,221	0.80	15,099	− 258	− 139	− 228	.....	+ 148
Ohio	1	45.5	4.58	8.10	14,888	1.75	14,626	+ 186	.....	+ 586	+ 264	+ 65
Ohio	4	42.9	3.97	7.04	14,965	2.38	14,642	− 12	+ 725	+ 280	+ 330	− 46
Ohio	5	42.8	3.66	9.01	14,832	3.83	14,431	+ 480	+ 572	+ 83	+ 463	+ 131
Okla	5	35.5	7.36	3.71	15,025	1.38	14,814	− 299	− 185	− 412	+ 450	− 182
Okla	6	40.8	2.06	7.35	15,061	1.57	14,825	+ 43	+ 461	+ 151	− 73	+ 43
Pa	1	38.3	1.38	6.94	15,345	1.42	15,127	+ 132	+ 445	+ 165	+ 32	+ 165
Pa	5	32.4	1.00	7.35	15,511	1.07	15,346	+ 509	+ 31	− 98	− 76	+ 411
Tenn	1	38.4	1.17	7.94	14,960	1.97	14,665	− 183	+ 60	− 248	− 35	+ 43
Tenn	2	33.8	0.95	6.70	15,320	1.08	15,137	− 290	− 40	− 211	− 286	+ 168
Tenn	3	39.8	5.73	5.14	15,125	1.32	14,921	+ 11	+ 365	+ 103	+ 310	− 82
Va	1	38.3	1.32	8.01	15,156	1.79	14,887	+ 142	+ 136	− 59	+ 77	+ 155
Va	2	40.2	0.85	12.18	14,918	2.52	14,381	+ 842	+ 158	− 233	− 88	+ 619
Va	6	35.3	0.97	5.65	15,291	1.49	15,069	− 344	+ 21	− 157	− 26	− 38
Wash	3	44.0	5.23	13.93	14,796	1.55	14,569	+ 9	.....	+ 305	− 284	+ 778
W. Va	5	44.3	3.86	7.06	15,291	1.58	15,048	+ 167	.....	+ 828	+ 478	+ 220
W. Va	6	40.0	0.72	10.10	15,107	2.11	14,787	+ 555	+ 347	+ 41	.....	+ 471
W. Va	9	36.4	0.73	5.14	15,448	1.36	15,237	+ 217	+ 238	+ 94	+ 14	+ 199
Wyo	8	39.3	0.99	11.40	14,848	2.13	14,552	+ 539	− 52	− 282	− 148	+ 417
VI. Bituminous, Medium Grade												
Ala	5	37.7	1.37	10.45	14,467	2.69	14,078	+ 187	− 553	− 858	− 430	+ 26
Alaska	1	44.2	1.85	14.11	13,838	2.55	13,484	− 673	.....	− 661	− 923	+ 217
Cal	2	53.8	4.80	11.47	14,336	5.19	13,593	− 13	.....	+1023	+ 51	+ 127
Ill	2	41.4	1.36	12.02	14,492	5.15	13,745	+ 477	+ 392	− 589	− 179	+ 245
Ill	3	37.4	1.14	8.46	14,621	6.02	13,742	− 164	− 499	−1016	+ 8	− 241
Ill	7	39.3	3.10	9.03	14,724	3.71	14,177	+ 160	− 176	− 521	+ 105	+ 85
Ind	1	40.9	2.88	9.50	14,492	5.48	13,698	− 58	− 108	− 678	+ 19	− 39
Ind	3	47.3	6.60	9.96	14,305	5.01	13,576	+ 169	.....	+ 76	+ 15	+ 37
Ia	2	51.2	8.53	8.96	14,206	5.35	13,445	+ 104	.....	+ 515	+ 609	− 118
Ia	3	40.6	6.64	8.03	14,555	6.24	13,647	+ 194	− 305	− 701	+ 540	− 128
Kan	1	44.2	9.94	5.64	14,724	4.09	14,121	− 12	.....	+ 81	+ 967	− 224
Kan	3	39.8	5.22	5.98	14,922	4.30	14,269	− 163	+ 49	− 333	+ 600	− 151
Ky	1	44.0	4.29	8.90	14,657	6.52	13,702	+ 137	.....	− 143	− 570	+ 37
Ky	5	43.5	5.64	7.46	14,836	2.98	14,394	+ 592	+ 736	+ 174	+ 447	− 41
Mich	1	38.8	1.53	9.54	14,999	4.70	13,818	− 234	− 401	− 880	− 203	− 7
Mich	2	37.1	1.11	10.51	14,603	5.59	13,786	+ 118	− 517	−1017	− 52	− 156
Mo	1	44.8	5.16	9.53	14,351	4.65	13,682	− 2	.....	− 208	+ 55	− 32
Mo	3	44.6	4.96	11.83	13,892	3.42	13,416	+ 165	.....	− 624	− 551	− 202
Mo	4	50.8	6.33	7.73	14,679	3.69	14,136	− 7	.....	+1026	+ 433	− 46
Mo	5	45.3	9.45	6.28	14,476	2.83	13,921	− 158	.....	+ 31	+ 618	− 229
Mo	6	50.2	6.21	6.12	15,134	5.68	14,276	− 66	.....	+1241	+ 941	− 72
Mont	5	34.3	4.86	9.50	14,134	2.42	13,791	− 10	−1226	+ 779	+ 414	− 207
Mont	8	39.6	0.60	9.77	14,681	2.30	14,342	− 188	− 79	− 428	− 343	− 555
N. Mex	3	44.3	0.68	12.70	14,539	3.06	14,093	+ 450	.....	+ 143	.....	+ 404
Ohio	2	37.8	0.63	11.58	14,269	4.69	14,152	− 19	− 751	− 651	− 527	− 111
Ohio	3	47.7	5.74	9.44	14,332	3.30	13,523	− 40	.....	+ 128	− 397	− 97
Okla	4	41.7	2.31	9.26	14,711	4.31	14,075	+ 25	−1000	− 287	+ 60	+ 42
Utah	1	45.6	0.60	13.30	14,245	4.98	13,536	+ 287	.....	− 219	− 509	+ 201
Utah	2	47.2	0.62	10.93	14,764	2.47	14,399	+ 190	.....	+ 674	− 244	+ 269
Wash	1	41.8	0.57	12.38	14,348	3.26	13,879	+ 142	− 52	− 553	− 686	+ 257
Wyo	9	39.6	0.84	9.25	14,793	2.73	14,391	+ 100	+ 32	− 343	− 164	0

TABLE 2 CLASSIFIED LIST OF COALS

	Order in Table 1	Combustible				Air-dry		B.t.u. Greater (+) or Less (−) than Estimated by				
						Ash-free		Combustible		Air-dry Ash-free		Dry Coal
		Vol.	S.	O.	B.t.u.	Moist	B.t.u.	Dulong Formula	Mahler Curve	F.C. Curve	Moisture Formula	$\frac{C}{C+O+A}$
VII. Bituminous, Low Grade												
Alaska	2	40.8	0.94	18.83	12,964	5.42	12,261	− 309	− 40	− 147	+ 23	− 176
Ill	1	46.0	6.33	10.53	14,263	6.75	13,300	+ 270	.....	− 245	− 299	+ 79
Ill	4	40.8	5.55	12.02	13,921	6.02	13,084	+ 263	− 679	−1264	− 195	− 3
Ill	5	46.2	6.02	10.09	14,155	10.59	12,657	+ 60	.....	− 708	+ 532	− 114
Ind	2	42.2	1.78	10.55	14,746	9.60	13,329	+ 347	+ 346	− 516	− 477	+ 234
Ind	4	44.8	6.73	9.69	14,089	6.17	13,220	− 16	.....	− 550	+ 120	− 130
Ia	1	47.5	5.69	9.73	14,305	11.33	12,684	− 114	.....	− 306	+ 680	− 94
Mo	2	47.3	4.85	10.68	14,202	7.37	13,156	− 5	.....	− 164	+ 149	− 49
Mont	1	33.3	12.99	6.82	13,693	2.37	13,368	− 164	−1708	+ 231	+ 75	− 140
Mont	2	44.4	1.72	20.44	13,338	8.75	12,170*	+1293	.....	+ 820	− 866	+ 565
Mont	3	43.7	2.00	15.87	13,162	6.34	12,324*	+ 13	.....	+ 724	−1266	− 600
Mont	4	37.5	0.86	16.21	13,865	7.58	12,813	+ 456	−1155	+ 588	− 356	+ 486
Mont	6	32.6	2.88	16.14	12,438	8.09	11,432	− 45	−3042	−1318	−1674	−2583
N. Mex	4	42.8	0.78	14.00	13,939	11.70	12,309*	+ 120	− 28	+ 997	− 107	+ 25
N. Mex	5	46.8	2.38	15.69	13,322	7.87	12,008*	+ 94	.....	+1046	− 699	− 122
Okla	1	45.9	5.93	10.62	13,667	7.74	12,609	− 133	.....	− 856	− 233	− 197
Ore	3	48.1	1.65	.....	14,618	11.88	12,882	+ 421	−3107	+ 27	+ 605	.....
Utah	3	38.4	0.56	18.13	13,118	5.60	12,384	+ 723	−1782	+ 109	−1522	− 89
Utah	4	45.4	7.27	10.05	13,586	9.65	12,276	− 189	.....	+1114	+ 35	− 676
Utah	5	44.0	7.10	14.18	13,081	11.47	11,374	− 103	.....	+ 287	− 108	− 443
Wash	2	47.5	0.44	17.11	13,423	6.56	12,548	+ 255	.....	+1411	−1134	+ 111

* Montana 2 and 3 and New Mexico 4 and 5 are classed as sub-bituminous in Bulletin 22 of the Bureau of Mines.

VIII. Sub-Bituminous and Lignite												
Ark	3	52.1	0.96	21.17	12,497	22.00	9,750	+ 496	.....	+ 75	−1190	−1960 L
Cal	1	53.5	4.62	16.79	12,890	10.95	11,478	− 107	.....	− 732	− 754	−1887 S
Colo	1	41.4	0.44	16.97	11,619	8.21	10,664	−1397	−1981	−1061	−2110	−1657 S
Colo	2	45.5	0.51	16.52	13,239	15.35	10,094	+ 223	.....	− 668	−1378	− 254 S
Colo	3	41.1	0.39	18.00	12,746	8.68	11,638	− 33	−1854	− 87	−1563	− 476 S
Mont	7	69.0	1.86	23.47	11,900	15.55	10,143	+ 146	.....	+1774	−1365	− 221 S
Mont	10	54.1	0.67	26.64	10,211	25.02	7,656	+ 162	.....	−1656	−3806	−2805 S
N. Dak	1	49.8	1.16	.....	11,398	13.93	9,801	.....	.....	− 599	−2044	 L
N. Dak	2	56.7	2.04	17.69	12,557	26.20	8,886	+ 297	.....	+ 61	+ 658	− 528 L
N. Dak	3	45.9	0.86	22.67	12,101	11.66	10,885	+ 544	.....	− 202	−1517	− 241 L
Ore	1	44.0	1.15	19.68	12,769	10.16	11,471	.....	.....	+ 183	−1579	− 43 S
Ore	2	47.0	5.52	.....	11,493	7.05	10,684	.....	.....	−1203	−2473	..... S
S. Dak	1	40.0	0.68	.....	12,098	15.77	10,189	.....	−2662	−1123	−1267	 L
Tex	1	59.5	1.46	18.99	13,043	15.73	11,077	+ 341	.....	+1729	−1801	+ 130 L
Tex	2	70.9	1.00	.....	10,811	23.58	10,169	.....	.....	+2002	−1003	 L
Tex	3	45.3	1.61	18.66	12,890	11.02	11,578	+ 452	.....	+ 382	−1908	− 117 L
Tex	4	49.6	0.90	20.54	12,452	11.82	11,036	+ 276	.....	+ 428	−2366	− 251 L
Utah	7	46.6	4.88	22.14	11,264	15.35	9,535	− 111	.....	−1115	−1670	− 730 B
Wash	4	54.6	0.53	22.06	12,226	17.21	10,122	+ 307	.....	+ 422	+ 14	− 183 S
Wyo	1	27.8	1.09	10.94	12,956	9.56	11,573	− 177	−2704	−1489	− 127	−1002 S
Wyo	2	44.3	0.36	24.35	11,722	9.75	10,581	+ 715	.....	− 706	−1353	− 427 S
Wyo	3	39.3	0.17	21.95	12,683	12.54	11,093	+ 847	−2217	− 544	−1177	+ 30 S
Wyo	4	59.9	1.18	23.41	11,194	24.09	8,496	+ 266	.....	+ 996	− 918	− 448 S
Wyo	5	47.5	4.04	17.06	12,447	18.84	10,103	+ 6	.....	− 222	− 317	− 622 S
Wyo	6	43.5	0.72	25.54	11,030	7.55	10,198	+ 521	.....	−1327	−3236	− 906 B
Wyo	7	50.6	2.17	29.86	9,630	22.69	7,458	+ 492	.....	−2317	−2263	−2383 S
Wyo	10	49.4	0.77	33.14	10,141	14.85	8,666	+1292	.....	−1751	−3068	− 486 S
Not Classified												
R. I.	1	6.6	0.05	5.59	13,120	1.26	12,955	− 749	−2170	−2173	−2037	−1410
R. I.	2	6.3	0.09	3.27	14,002	0.52	13,930	− 207	−1208	−1138	−1237	−1536
Alaska	5	21.7	10.76	5.28	13,945	4.77	13,279	− 287	−1885	−1046	+ 297	− 313
Ark	4	21.0	1.43	6.44	14,945	1.77	14,722	.....	− 895	− 13	+ 7	− 41
Idaho	1	50.9	4.77	.....	16,457	16.42	13,757	.....	.....	+1607	+2972	.....

L, Lignite; S, Sub-bituminous; B, Bituminous; Classification of the U. S. Bureau of Mines.

Wyoming 6, Sample taken 10 ft. from entrance, coal very much weathered; Wyoming 7, Surface exposure; Wyoming 10, Shallow prospect pit, coal badly weathered.

The Rhode Island coals are graphited and are not used as fuel. Alaska 5 and Arkansas 4 may be classed as semi-bituminous by their percentage of volatile matter, but they are higher in oxygen and in moisture, and lower in heating value than other semi-bituminous coals. The Idaho coal is apparently a cannel coal very high in moisture, but the ultimate analysis is lacking.

B.t.u. per lb. S, and dividing by 1 minus (% S÷100), the value thus found is often far higher than the heating value per pound of combustible of coals of the same districts that are low in sulphur. In Fig. 2 the results thus obtained are plotted, the high value referred to being shown at the upper right hand of the diagram, marked "high sulphur coals, heating values fictitious." Lower values for these coals might be found if they were converted by the "unit coal" method of Parr and Wheeler (Bulletin 37, 1909, of the Illinois University Engineering Experiment Station) viz.

$$\text{B.t.u. per pound unit coal} = \frac{\text{Indicated dry B.t.u.} - 5000\,S}{1.00 - (1.08\,\text{ash} + 0.55S)}$$

The next attempt at relating the heating value of these coals to their chemical composition was by the method of David White, modified by converting his ratio $\frac{C}{O+A}$ into percentage $\frac{C}{C+O+A}$. A straight line whose formula is B.t.u. $= 16500 \frac{C}{C+O+A}$, may be drawn through the plotted points, but the variations of many of the points from the line indicate that the method is of little if any practical value (see Fig. 3).

Fig. 4 shows the result of plotting the B.t.u. per lb. of air-dry coal free from ash to the fixed carbon. By this method the coals are apparently divided into two principal classes: (*a*) high-grade coals including as subdivisions, anthracite, semi-anthracite, and the Appalachian and other good bituminous coals; and (*b*) low-grade Western coals and lignites. The variations from the average lines drawn through the plotted positions are in many cases so great that this method cannot be considered as of any value.

Fig. 5 shows the result of plotting the heating value per pound of air-dry coal and ash and sulphur free, against the percentage of moisture in such coal, for those cases in which the moisture does not exceed 11 per cent. The results indicate that this method may prove to be of considerable importance when it is applied separately to the coals of different states or districts, especially the bituminous coals of the Middle West. The high position of the Kansas coals and of one of the Missouri coals may be due to the error of the common method of correcting for sulphur.

After studying the coals by the method of plotting as described, Table 2 was constructed, in which a revised classification is attempted. The last five columns show the differences in B.t.u. per lb. between the B.t.u. per lb. given and those that result from calculation by Dulong's formula, by the Mahler curve, or by the average lines of Figs. 3, 4 and 5. The extent of these differences suggests that in some cases the calorimetric determinations, or the analyses, or both, may be in error and indicates the necessity for thoroughly checking the loss in air-drying, the moisture determinations of the air-dried coal, the analyses, proximate and ultimate, and the calorimetric work. The revised classification is given in Table 1.

DISCUSSION

P. F. Walker. I believe that Mr. Kent's paper throws considerable light on the coal question, but am inclined to believe that the results are of more value negatively than positively, so far as the estimation of heating values from proximate analysis is concerned.

Very shortly after coming into the Western country, nine years ago, and beginning to use the lower grades of bituminous coal in Kansas and western Missouri, I found that the heat values per pound of combustible, as published by Mr. Kent and based on his study of Mahler's researches, did not apply. Not only did the coal in general fail to match up with Eastern coal, but marked differences within a comparatively limited area occurred. This was not so surprising when one considers that some of the coal measures now being worked in Kansas are situated, stratigraphically, 2000 ft. above others.

Many of us would like to see some method established by which heat values could be estimated with a fair degree of accuracy from the proximate analysis, thus avoiding the more exact and laborious methods of the ultimate analysis and the calorimetric test alike. It is not so important to know the exact position of a given coal in a classification established on chemical properties as to know its value in heat. Is there, then, any method by which the quick and reliable estimate may be made? And more specifically, does the study of government analyses here presented to us, go far in this direction?

Emphasis is laid in this paper on air dried coal, with especial reference to its moisture content and fixed carbon content. The entire question of moisture content of coal is a complex one. In the work of analysis by the United States Bureau of Mines, air drying of samples was carried out as a laboratory convenience. The sole purpose was to bring the coal to the condition of the surrounding atmosphere to prevent change of weight during handling and weighing. In the process, air was warmed and drawn through the dryer at from 10 to 15 deg. fahr. above room temperature. The heating lowered the humidity percentage, but in all cases, the absolute degree of humidity was dependent upon the temporary conditions of the atmosphere. In the same laboratory, therefore, there might be marked differences in the extent of drying the coal at different seasons of the year as the humidity is changed far more in heating the air during the cold winter months. Also, more marked differences might occur among laboratories located in various parts of the country.

It will be observed that one set of values in Mr. Kent's table is based on moisture remaining in the coal after air drying, and the chart indicating relation of heating value to moisture in air dry coal, shows that the quantities involved are of small magnitude. Differences due to varying atmospheric conditions or varying laboratory methods, or both, are thus thrown on a relatively small quantity, and the result is apparent. The variation in fixed carbon values because of such laboratory inaccuracies as these would not be so pronounced, but the wide fluctuation of values on the Fixed Carbon basis, as shown in another chart, is due to

another well established cause. This cause is the same as that which makes the estimate by the earlier Mahler method inaccurate; namely, in the low grade bituminous coals, the volatile gases are made up of numerous hydro-carbon constituents, differing so widely in the amount of carbon which they carry from the fuel, that the solid or fixed carbon does not represent the real condition as to heat value in any such degree of regularity as is found in the case of the anthracite and other high grade coals.

A very brief analysis of results given in the final tables of the paper will show the extent of these variations. For the high grade bituminous coals, in the moisture formula column, it is seen that the variations range from —447 to +908. This means that in an estimation of heat value, the error ranges from 3 per cent high to 6½ per cent under. For the medium grade bituminous coals, the range is from —923 to +967, or from 6.4 per cent high to 7.3 per cent over. For both grades of coal, corresponding figures from the Fixed Carbon column show variations considerably greater than these even. A glance at the values in these two columns for the medium grade bituminous is sufficient to show the great magnitude of the variations between true values and these estimates.

The information presented in these tables and charts is most valuable, but I am forced to the conclusion that the way out for a simple and direct method of estimating heat values is not yet in sight. The direct calorimetric determination is a process, the labor and time for which are soon equalled by the labor and time spent in multiplying the steps in the proximate analysis and its result is to be trusted in far greater measure than that from the other can ever expect to be, especially when dealing with the lower grades of fuel. In my opinion, the most fruitful field for study in this connection is the volatile matter with its ever-changing character with respect to carbon and hydrogen content.

A. G. Christie. I am inclined to agree with the opinion of Professor Walker that a proximate analysis is no reliable indication of the heating value of coal. In this connection I wish to refer to a bulletin recently published by the University of Wisconsin by Mr. O. C. Berry on the tar forming temperatures of American coals. The object of the investigation was originally in connection with gas producer work, but incidentally we found out a number of things about American coals that were embodied in that bulletin.

From investigations of the low grade coals which you get in the West, the variations in the character of the volatile matter become very prominent. It seems as though the volatile matter contained variables such as Professor Walker has stated in the carbon-hydrogen content. And also there seemed to be indications that in coals of the lignite and semi-lignite series, there were combinations of what one might call acetic and carbolic acid derivatives. Time was not available to go into an investigation of these combinations, but there did seem to be considerable quantities coming off where tar was expected. The tar from the Western coals was comparatively slight in amount and yet the volatile matter was extremely high. That would seem to indicate that there were combinations present which were not of high carbon-hydrogen ratios. The heating values of these coals were low. We found that a better indicator than any proximate analysis was shown by the ultimate analysis considering only the ratio of the carbon and hydrogen.

The Author. Referring to Mr. Christie's statement that "a proximate analysis is no reliable indication of the heating value of a coal," it would be strictly true if he added to it the words "when the volatile matter is more than 35 per cent of the combustible." When thus modified the statement would be in exact accordance with what is said in paragraph 8 of my paper, viz.: "The plotting shows that all the coals of the Appalachian field, cannel coals excepted, come close to the original curve drawn from Mahler's tests of European coals when the volatile matter in the combustible is 35 per cent or less. For coals higher in volatile matter and for Western coals generally, the heating value varies over a wide range and appears to have no relation to the volatile matter, but each district has a law of its own.

Undoubtedly, as Mr. Christie says, the character of the volatile matter in the Western coals differs widely. The chief difference is in the percentage of oxygen. For example, in seven Illinois coals the oxygen ranges from 22.3 to 29.0 per cent of the volatile matter; in six Ohio coals it is from 16.6 to 30.6 per cent; in four Oklahoma coals it is from 10.5 to 22.2 per cent, and in five Montana coals it is from 20.5 to 46.0 per cent. The percentage of oxygen might be taken as an indication of the heating value of these coals, but it is only a rough indication, for it appears that in some coals high in oxygen, part of the oxygen may be combined with carbon, instead of all being combined with hydrogen as it is assumed to be in Dulong's formula. The carbon-hydrogen ratio, for the same reason, can never be anything more than a rough indication of the heating value, for the variation in this ratio is a consequence of the variation in oxygen. If oxygen is high the carbon-hydrogen ratio must necessarily be low, as the hydrogen in all the high oxygen coals varies but little. In future studies of coal it is desirable that the carbon-hydrogen ratio be expressed as a percentage of C or H divided by C + H, for the reason given in the paper.

Professor Walker's statement that the results are of more value negatively than positively, as far as the estimation of heating value from proximate analysis is concerned, is correct for most of the coals mined West of the Mississippi River, and for all coals containing more than 35 per cent of volatile matter in the combustible; but there certainly is a relation between the proportion of volatile matter and the heating value in all the Eastern coals and also those of Oklahoma and Arkansas, when the volatile matter in the combustible is less than 35 per cent. It also appears that in the coals mined East of the Mississippi, as shown in the paper, there is a relation between the heating value and the moisture in the air-dried coal free from ash. In future studies of coals of particular districts, such as those of Indiana and Illinois, this relation should be investigated. This relation appears notwithstanding the probable variations in the recorded moisture, due to the variation in humidity of the atmosphere in which the coals were dried, but in future researches it should not be difficult to obtain an atmosphere of standard humidity for drying purposes, by means of a chamber in which the moisture is controlled by a hygrostat at the same time that the temperature is controlled by a thermostat.

MEETINGS

NEW YORK, OCTOBER 21

The opening meeting of the Fall in New York was held October 21, at which an interesting and timely paper was read by F. A. Waldron on Panic Economies and Emergency Problems with Special Reference to the Present Industrial Situation. The paper was well received and elicited some interesting discussion. It is published in full, with the discussion, in this issue of The Journal.

ST. PAUL, OCTOBER 22

At a meeting of the Minnesota Section held in St. Paul, October 22, 1914, Adolph F. Meyer presented his paper, Power Developments on the Mississippi River between St. Paul and Minneapolis. A large number of lantern slides, showing the construction in detail from the commencement to the present stage of the work, were used by the author. The paper was discussed by those present.

BUFFALO, OCTOBER 22

A meeting of the engineering profession of Buffalo on October 22 was addressed by Charles Whiting Baker on the topic, Engineers and Public Service. Mr. Baker spoke of the effect of the war on the world, showing a unity undreamed of in the time of Napoleon. This physical unity, he said, has been brought about by the engineer with his steamships, railroads and cables. He emphasized further the necessity for building and operating public utilities in a modern city by competent engineers and predicted radical changes during the next few years. Public sentiment is leaning more and more towards municipal ownership and operation of city utilities, and the question of their application arises. This, he said, depends entirely upon local conditions. The engineering profession must do its part by supporting the men who are chosen to fill high positions, and the engineering societies, national and local, must do all in their power to help raise the standards of public service.

LOS ANGELES, OCTOBER 28

An organization of the Los Angeles Section was held on October 28 and the by-laws were briefly discussed. A very interesting paper on Local Transportation was read by George A. Damon, dean of Throop College of Technology, outlining the desirable developments and pointing out the difficulties to be met with. The cost factors entering into the problem and the influence transportation plays in the development of our cities were dealt with, also the four main methods of transportation, surface, elevated, open cut and subway. The paper was illustrated by lantern slides, and was discussed by C. K. Mohler, transportation engineer for the city of Los Angeles, F. C. Finkle, and others.

NEW YORK, NOVEMBER 10

At the monthly meeting of the Society in New York for November, Arthur H. Lymn of London, England, delivered an address on The Development of the By-Product Gas Producer Industry in Europe. He referred to the various stages of the remarkable progress that has been made in this field, and discussed the economic possibilities from the recovery of by-products, and referred in particular to results attained with the Lymn process, of which he is the inventor. The lecture was illustrated with lantern slides and drew out some discussion.

NECROLOGY

CHARLES F. BAKER

Charles F. Baker was born at Shoreham, Vt., January 22, 1855, and in his boyhood moved with his parents to Wisconsin. He received his technical training at the University of Illinois, and his first work was with the E. P. Allis Company of Milwaukee. During his service with the company Mr. Baker had charge of some of their largest work, including the pumping engines for Allegheny City and the blowing engines for the Edgar Thompson Steel Works at Braddock, Pa. He left the Allis Company to take charge of the installation and operation of the steam plant of the C. A. Pillsbury & Company flour mill at Minneapolis.

In 1893 Mr. Baker entered the employ of the West End Street Railway Company of Boston, now the Boston Elevated Company, and ultimately became superintendent of motive power and machinery in charge of all power plants and car shops. This work included the maintenance, inspection and design of rolling stock, shops and power stations and under his supervision the East Boston, Charlestown, Dorchester and Harvard Square power stations were built. In 1905 Mr. Baker entered the employ of the Brooklyn Rapid Transit Company as superintendent of power and machinery, and while there had charge of the reconstruction of the Kent Avenue station. He then went to Baltimore as superintendent of power and construction of the local street railway, and later became associated with the Hudson and Manhattan Company as superintendent of equipment of the power station and substations.

Later Mr. Baker joined the forces of the Bay State Street Railway in Massachusetts in charge of new construction and power plant reconstruction. During this period and until the time of his death on May 21, 1914, Mr. Baker, who had meantime removed to New York to promote a very effective cooling system for generators, was engaged in private consulting engineering practice with special reference to power station economies.

Mr. Baker was a member of the New England Street Railway Club. In 1904 he was elected president of the American Railway Mechanical and Electrical Association and was also the past president of the New England Steam Railroad Club of Boston.

CHARLES W. RICHARDS

Charles W. Richards was born December 4, 1867, in New York City and received his education in the public schools. He served his apprenticeship with Joseph Edwards & Company of New York. In 1887 he entered the employ of Henry R. Worthington & Company, as machinist, and was subsequently connected with the Boston Heating Company as assistant engineer, with the United Electric Traction Company as construction engineer, with the Cumner-Richards Company, in Boston, electric construction business, with the Consolidated Electric Car Lighting Company as general manager, with Stone & Webster, in electric railroad construction, with the sales department of Chase-Shawmut Company and that of the Simplex Electric Heating Company, with the Boylston Manufacturing Company, as superintendent, and with the Stevens-Duryea Company, of Chicopee Falls, Mass., as superintendent. At the time of his death he was manager of the Driggs-Seabury Ordnance Corporation of Sharon, Pa.

Mr. Richards was a member of the Society of Automobile Engineers, and had served on the board of directors of the Connecticut Valley Metal Trades Associations.

HENRY K. ROWELL

Henry K. Rowell was born June 1, 1870, at Charlestown, Mass., and after completing his education in the public schools, entered the office of E. A. Buss, mill engineer, in Boston. He was subsequently connected with Lockwood, Greene & Company, and during the last eight years with Charles T. Main. Mr. Rowell's experience in mill work was very extensive and he was responsible for the organization and construction of many well known plants, including the textile plant of the Edwards Manufacturing Company, Augusta, Me., the textile plant of the Pepperell Manufacturing Company, Biddeford, Me., the woolen weave mill of S. Slater & Sons, Inc., Webster, Mass., and many others.

Mr. Rowell made studies, reports and valuations on many mills and wrote a number of monographs, one of which, Organization of the Carding Department in Cotton Mills, read before the National Association of Cotton Manufacturers in 1911, deserves special mention.

He died at his home in Waltham, Mass., on August 9, 1914.

JOHN CHRISTIAN HENRY STUT

John Christian Henry Stut was born in Germany on January 11, 1851, and was educated in public and private schools. He served his apprenticeship in Germany and in 1870 came to the United States, entering the Union Iron Works in San Francisco as a draftsman. He also served an apprenticeship with several firms in the same city. He designed the plans for the American Sugar Refinery in that city in 1885, and acted as constructing engineer for the Cable Railroad, during his association with the Omnibus Cable Company. He was also associated with the Presidio & Ferries Railroad of San Francisco and the California Street Cable Railroad as constructing engineer, and designed the plans for the Alameda Sugar Company at Alvarado, Cal.

At the time of his death Mr. Stut had for a number of years conducted a private consulting business, specializing in cable and electric roads, sugar refineries, etc.

WARREN H. TAYLOR

Warren H. Taylor, one of the best bank lock and fine lock experts in the country, and superintendent of the bank lock department of Yale & Towne Manufacturing Company, died at his home in Stamford, Conn., on June 11, 1914. Mr. Taylor was born in Winchendon, Mass., February 17, 1846, and was educated in public and private schools. He served an apprenticeship as a machinist with his uncle in Milford, N. H.

When the Civil War broke out Mr. Taylor, though quite young, enlisted in a New Hampshire regiment, but was prevented by illness from going into service. Upon his recovery he returned to his trade of machinist, entering the employ of a sewing machine company at Winchendon, where he remained a year and a half. Subsequently he worked for the Smith & Wesson Arms Company, Springfield, Mass., the Remington Arms Company, Ilion, N. Y., for a lock company founded by Linus Yale's father at Newport, N. Y., and for Linus Yale, Jr., at Shelburne Falls, Mass., with the company which has since become the Yale & Towne Manufacturing Company of Stamford. In the spring of 1868 Mr. Taylor went with Mr. Yale to Stamford and was with the firm until the time of his death. The many inventions and patents which have been issued to him in conjunction with the manufacture of their products, numbering over 200, are universally known.

During his many years of service with the company he was associated with about every branch its operations cover. It is an interesting fact that at the beginning of his service he was associated with the bank-lock department and at the end he was the head of the department. During about ten years he acted as general superintendent of the company. Most of Mr. Taylor's inventions had to do with pin locks, but he made a number of important inventions in connection with post office lock boxes which have been used by the United States Government.

Mr. Taylor took an active interest in public affairs and was a member of the Board of Appropriation and Apportionment. He was one of the charter members of the Board of Trade. He was a member of the Stamford Yacht Club, the Democratic Club of New York, and the Reform Club of New York.

WILLIAM DEHERTBURN WASHINGTON

William DeHertburn Washington was born June 29, 1863, and died August 30, 1914, in Hanover County, Virginia. He received his early education at private schools and at the Maryland Agricultural College, where he took a special course in mathematics with a view to entering the United States Naval Academy. He changed his plans, however, and at the age of sixteen began work on an engineering corps of the Canal and Iron Railway. He was afterwards assistant resident engineer on the construction of the West Virginia Central & Pittsburgh Railway, and later in the office of the Atlantic & Pacific Ship Canal Company. He entered the employ of C. W. Hathaway & Company as a designer of special machinery, and designed many original mechanical devices, including steam engines, air separators, methods of hydraulic sheet piling, and a system of sinking caissons hydraulically, which has been successfully used in many of the large buildings in New York City.

At the time of his death Mr. Washington was president of the Hydraulic Construction Company, New York, which has engineered and constructed many important industrial plants in the United States. He was appointed by Governor Sulzer as consulting engineer to the Highway Commission of the State of New York, and was a delegate to the Third International Road Congress. He was a member of the American Society of Civil Engineers, the American Institute of Mining Engineers, and a fellow of the National Geographical Society.

FOREIGN REVIEW AND REVIEW OF THE PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

WITH this issue the Foreign Review enters into the third year of its existence. While formerly considerations of space permitted only the abstracting of periodicals printed in foreign languages, it has now been found possible to extend this section of The Journal so as to cover also the proceedings of various engineering societies. The Library of the Engineering Societies receives official publications of 132 engineering societies from all over the world, many of them practically inaccessible to anybody outside of the City of New York. While not all of them contain material of intrinsic interest to the mechanical engineer, there is certainly a vast amount of material presented in a skillful manner, and valuable information on various engineering problems of the day. The abstracting done must of course be kept within the space available for this purpose, but an attempt will be made to have, as far as possible, all the main engineering data contained in the paper or investigated either included in the abstract or fully referred to.

The Review in its new constitution will be divided into two sections: the Foreign Review, and the Review of the Proceedings of Engineering Societies. At the end of the year a common index to both sections will be published. As heretofore, wherever necessary, all values, when quoted in European units, will be given also in corresponding American units, and all the other features of the Foreign Review, such as the Supplementary References to articles previously abstracted, will be retained and extended to the new section as well.

THIS MONTH'S ARTICLES

In the section of Compressed Air Machinery the Meyer flat spring valve for air compressors is described, and is nearly the simplest that can be made. In the next section is shown the Bucherer inhalator-vaporizer working on the principle of the medical inhalator; its interest lies in the fact that with a heavier fuel it uses a larger nozzle which ought to help to avoid clogging of the nozzle; the same vaporizer can be made for kerosene engines with two float chambers.

A German installation for autogenous welding on a very large scale is described; the plant provides enough acetylene to take care of 50 welding burners, some of them of very large size, and has an overall output five times as large as is necessary to light a city of 5000 inhabitants, and *is run by one man only*. Of particular interest is the description of the devices insuring safety of operation. In the Chopovski process for electrical case carbonization is described a method which appears to be as yet only in the experimental stage, but, which, if properly developed will give a process permitting the full control of the thickness of the cementation layer of steel. Refrigeration engineers, particularly those who have to design apparatus for tropical countries, will be interested in the Plank process for increasing the output of CO_2 refrigerating machines working with high condenser pressures. In the section Steam Engineering several interesting devices are described, such as the Gestra valve for blowing off boiler deposits (the author claims that the boiler should be blown off for a couple of seconds every two or three hours); the Eimert battery for increasing the output of firetube boilers without increasing the space taken up by them. In the same section will be found an interesting discussion on the friction of gases against the walls of brick passages based on tests made by the author in a Russian steel plant. An extensive abstract is given of the article by Neumann on the efficiency of the Bone-Schnabel boiler in view of the scarcity of material referring to this new type of steam generator which just now is attracting much attention in Germany.

In the Review of the Proceedings of the Engineering Societies will be found an extensive abstract of Professor Lucke's paper before the American Gas Institute on the still somewhat mooted subject of surface combustion, to which, in connection with the use of the Bone-Schnabel system for boilers, is also devoted the article of Neumann in the Foreign Review section. To the class of papers dealing with the same subject, search for a cheaper fuel, belongs the paper by James Lord on the use of pulverized coal. While it deals mainly with the metallurgical aspect of this problem, in the abstract of the discussion which followed, data will also be found on the application of this new fuel to steam boilers. How to adapt the boiler to the coal available, and in particular the water-tube boiler to Southern highly volatile coal, is the question discussed before the Western Society of Engineers by H. Kresinger and Walter T. Ray, who, by a series of tests show that modified baffling may give very gratifying results.

After the subject of getting heat from the fuel comes that of using it in the most economical manner. In this connection attention is called to the paper on saving of heat units in marine machinery, by H. C. Dinger, before the American Society of Naval Architects. The description of the Power Supply on the Rand, given by A. E. Hadley before the British Institution of Electrical Engineers, describes a large power system selling, on a large scale, compressed air, in addition to electricity, and, among other things, confirms the commercially important fact that compressed air in large quantities can be transmitted to fairly long distances without losses that would make the operation of the system prohibitively expensive.

A rather complete abstract is given of the interesting paper by Prof. A. H. Gibson before the British Institution of Mechanical Engineers on the design of volute chambers and guide passages for centrifugal pumps.

Attention is also called here to the paper of A. H. Sabin on painting structural steel, to be presented before the American Society of Civil Engineers in January 1914; the description of an electric dynamometer designed by Nathan C. Johnson, and articles on the use of lignite coal for locomotives, boiler scale prevention, etc. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

FOREIGN REVIEW

Aeronautics

Numerical Estimation of Longitudinal and Lateral Stability of Airships (*Zahlenmässige Wertung der Längs- und Seitenstabilität von Flugzeugen*, R. Skutsch. *Zeits. für Flugtechnik und Motorluftschiffahrt*, vol. 4, no. 21, p. 281, November 15, 1913. 3 pp., 2 tables. *c*). The author derives certain coefficients for longitudinal and lateral stability of aeroplanes, and gives a table of values of the magnitudes entering into their equations for a large number of monoplanes and biplanes covering practically the entire field of machines of commercial importance. Some data are taken from hitherto unpublished materials, such as original drawings of apparatus which has not apparently been described in print.

Technical Impressions of the Exhibition Flights of Pégoud (*Technische Impressionen vom Schaufluge Pégouds*, F. Ellyson-Edelstein. *Zeits. für Flugtechnik und Motorluftschiffahrt*, vol. 4, no. 21, p. 284, November 15, 1913. 11 pp., 7 figs. *d*). Description of the Bleriot apparatus and starting devices used by Pégoud in his exhibition flight at Aspern (near Vienna, Austria) and Johannistal, Germany, and a very interesting analysis of the methods which allowed him to fly upside down, loop the loop, etc. The author comes to the conclusion that it was the inherent lack of stability of the apparatus used that permitted Pégoud to perform safely all his evolutions, which he could not do unless he had an apparatus conforming to the following conditions: supporting planes of the most simple geometric form; unenclosed, short, rectangular hull with rounded edges; large steering planes; horizontal rudder convex bottomward; a light carriage, and an indifferent position of equilibrium. These conditions, however, are also the typical characteristics of an inherently unstable machine. The author attaches great importance to the demonstrations of Pégoud in that he has not only given valuable data for future constructors of airships, but has shown to the general public that, in the hands of the right men, flight has already become one of the safest means of locomotion.

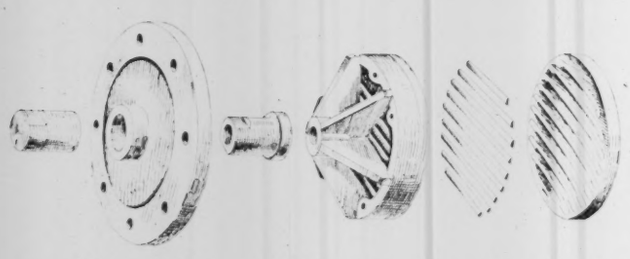


Fig. 1 Myer Flat Spring Valve for Air Compressors

Compressed Air Machinery

The Production of Compressed Air and Its Application in Shops (*Die Erzeugung der Druckluft und ihre Verwendung in Fabrikbetrieben*, A. Wallichs. *Die Fördertechnik*, vol. 6, no. 10, p. 227, serial article not finished. *d*). Among other things, the article contains an interesting description of the *Meyer flat spring valve for air compressors*. The tendency towards the use of light valves began with the successful introduction of the Rogler and Hoerbiger valves, endeavor lately, at least in Germany, having been in the direction of designing the valve as simply as possible. Fig. 1 shows what appears to be nearly the simplest possible design, the simplicity in this case having been attained by the use of a flat spring valve. The "lift" of the valve is effected by the bending of separate lamina, independent of one another. The article states that sufficient data are still lacking as to whether this construction will stand long wear, and especially as to whether the spring lamina will remain air-tight after continued use. The article describes also the latest types of the Hoerbiger valve, the Thyssen valve (four crosswise superimposed springs pressing uniformly on the plate ring valve at four places, while in the free segments are arranged the valve stops), and the Borsig valve, in which the valve and guide are combined through the guide being machined out of, and remaining in permanent connection with, the valve plate itself.

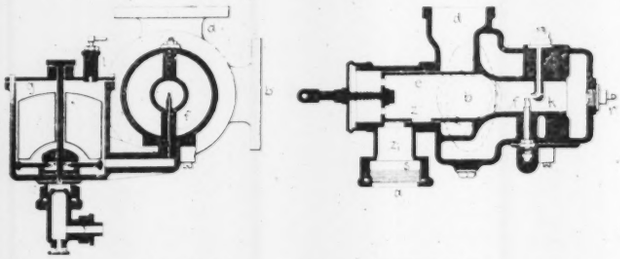


Fig. 2 Bucherer Inhalator-Vaporizer

Internal Combustion Engineering

The Bucherer Inhalator-Vaporizer Patented in Germany (*Der Bucherer-Inhalator-Vergaser (D.R.P.)*, B. *Der Motorwagen*, vol. 16, no. 28, p. 706, October 10, 1913. 1 p., 2 figs. *d*). The Bucherer inhalator-vaporizer may be used with engines of any number of cylinders. It is based on a principle materially similar to that of the inhalator used in medicine. The cold atmospheric air enters at *a*, the warm engine air at *b*, and the explosive mixture goes to the engine through the connecting tube *d*. The nozzle *f* communicates with the float chamber *g*, and the nozzle *k* with the atmosphere. The float chamber *g* in its turn is connected with the suction piping by a pipe *r* in a manner such that the same pressure ratio is maintained in both. The fuel is therefore delivered to the fuel nozzle not by the partial vacuum in the suction piping but by the inhalator action of the air nozzle *k*. The fuel liquid drops slowly from the nozzle *f*, and, at the instant of dropping, is torn away by the powerful action of the stream of air coming from the nozzle *k* and atomized in a very complete manner. The action is practically the same as that of a mouth-spray used by street venders of flowers. The cover of the float chamber *g* is provided with an air valve *l* usually closed. If, however, owing to change in the quality of fuel, change of climate, etc., a small adjustment in the quantity of fuel becomes necessary, it is enough to open somewhat the valve *l* in order to change the volume of flow of fuel through the fuel nozzle *f* which is of constant section. The action of the valve *l* is due to the fact that, even though the air entering through it is immediately sucked away along the pipelet *r*, the flow of air through the float chamber produces a small rise in pressure in it, and thus facilitates the injector action of the nozzle *k*. Since the velocity of flow through the nozzle *f* is considerably below that through the usual spray

nozzles, it has to be made of larger cross section; this results in the fact that even in the case of low power engines with a small consumption of fuel, clogging of the fuel valve is made practically impossible. At the same time, owing to the larger cross section of the fuel nozzle, a very small opening of the valve *l* causes quite a substantial change in the flow of fuel, without in the least affecting the inhalator action of the air nozzle. With the usual spray nozzles the use of heavier fuels involved a smaller nozzle (so as to have a greater pressure per square inch in the nozzle); in the inhalator vaporizer, on the contrary, a larger nozzle has to be used. At the same time it is well known that the action of the air nozzle is extremely powerful (the mouth-spray is strong enough to atomize kerosene oil to an impalpable fog), and the powerful blast caused by a nozzle actuated from a running engine is fully sufficient to atomize fuels of far greater consistency than kerosene.

The throttling of the engine is done by the piston valve *e*, of which the conically machined end acts as a valve seat, and can cut off entirely the flow of the mixture. Supplementary air flows through z-z_1, while *s* shows a wire gauze net which may be installed in order to prevent carbureter fires on aeroplanes or where there are inflammable materials around. In aeroplane and kerosene engines the vaporizer is provided with two float chambers, in the first in order to set instantly into action the other float chamber should the fuel supply pipe in one break, and in kerosene engines because one float chamber works on the regular fuel, and the other on gasolene or benzene for a start. By a slight adjustment in the opening or closing of the valve *l* the same vaporizer may be made to work with either light or heavy benzene or with benzole. The device is of particular interest because the cheaper grades of fuels may be used in it.

Movable Models for the Explanation of the Airship Engine (*Bewegliche Modelle zur Erklärung des Luftfahrzeugmotors*, -h-. *Deutsche Luftfahrer-Zeitschrift*, vol. 17, no. 22, p. 531, October 29, 1913. 1 p., 5 figs. *d*). The aviator must thoroughly know his engine, so as to be able to detect defects in its working before it actually stops running. As in most cases he cannot handle an engine long enough to become familiar with all the details of its construction, it is believed that a work on a set of properly constructed models might be of advantage; this applies also to the case of large schools where each particular student has only a limited time to devote to the study of the engine. The article describes and illustrates a set of models placed on the market by a German firm, giving a sectional view of the engine, the piston motion, valve motion, etc. All the models are movable, are provided with brief explanatory notes, and appear to be of use for their particular purpose. Two additional models show the operation of the carbureter and of the ignition system, two subjects of particular importance to an aviator.

Machine Shop

Autogenous Welding in Shop Practice on a Large Scale (*Die autogene Schweissung im Grossbetrieb*, J. Knappich. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 36, no. 47, p. 571, November 21, 1913, 3 pp., 6 figs. *d*). The Augsburg-Nuremberg Machine Company was one of the first German concerns to employ autogenous welding on a large scale; its installations for this purpose have been continually enlarged, and last spring a large special plant was installed, said to be the last word in this branch of engineering. Fig. 3 A and B shows section and plan respectively of the installation. The carbide storeroom located near the machine room *A* is separated from the latter by a fireproof wall with a fireproof door, and has a storing capacity of 10,000 kg. (22,000 lb.). The generation of the acetylene is carried on on the so-called deep generation system, i.e.,

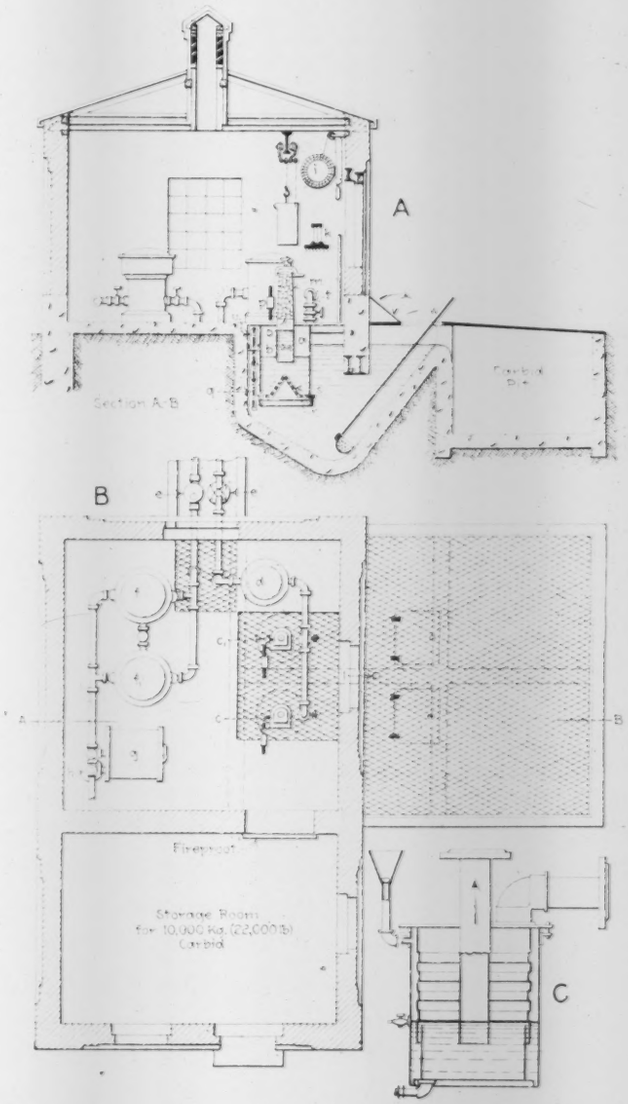


Fig. 3 Acetylene Generating Plant (Autogenous Welding) of the Augsburg-Nuremberg Machine Company

with the generator direct in the water space. This system was adopted because in plants of this size a very important element is that of removing the carbide residues, and for this purpose it is well to have as large a water reservoir as possible, which can be best done with the "deep" system. As shown in Fig. A and B, the machine plant consists of two generators *c* and *c'* for 50 kg., carbide each, the washer *d* with the water closing device *e*, a gasholder (standing in the open) of 30 cu. m. (1059 cu. ft.) useful volume, cleaners *f* and *f'* of 0.25 cbm. (8.8 cu. ft.) useful volume, station gas meter *g* with a capacity of 31 cbm. (1094.7 cu. ft.) per hour; Knappich central safety water

reservoir *h* (more of it below); gasholder contents indicator *i*, water manometer *k* and emergency lighting *l*.

After being generated in the generators *c* and *c'*, the acetylene flows through the washers *d*, which serve also as water seal, to the gasholder, from which, when required, it flows through the two cleaners *f* and *f'*, gas meter *g* and the Knappich safety water reservoir *h*. By these means the impurities contained in the acetylene and soluble in water, such as ammonia, hydrogen sulphide, etc., are eliminated from it at the same time that it is being generated and stored away; on the other hand, such impurities as hydrogen phosphide, hydrogen silicide, etc., are retained by chemical means in the cleaners *f* and *f'* on the way to consumption (because here the gas flows with less velocity). The acetylene reaches therefore the place of consumption in a state of technical purity, which is very important for the production of good welds.

The generator is always surrounded by a large quantity of water which helps to obtain both an economical gasification of the carbide and a gas free of products of polymerization (owing to the fact that the excess of water provides an effective cooling). Further, since every generator has a capacity of 50 kg. carbide and a production of 15 cbm. (530 cu. ft.) of gas, the amount of air which gets into the charging chamber with the carbide may be considered as negligible, and the formation of explosive mixtures practically eliminated.

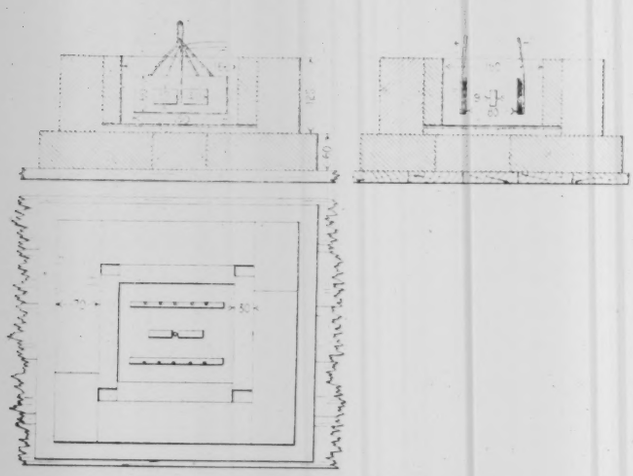


Fig. 4 Apparatus for Electric Case Carbonization

In the cleaners which have to take care of the impurities not readily soluble in water, a product with a chromic acid basis is used (its exact composition is not stated). The cleaners are sealed hermetically by a bell partly submerged in water and provided with an automatic alarm whistle indicating low level of the water seal.

The purpose of the gas meter is to determine the consumption of gas in the plant, as well as the gas output per unit of calcium carbide used. (The latter is especially important in Germany, as under the standard contract of the German Acetylen Society, the carbide factories guarantee a certain output of gas per unit weight of carbide.) In addition to the gas meter, the plant uses a special apparatus (of Dr. Caro) for the determination of gas production from carbide. The water manometer is arranged so that it can be connected with any part of the plant, though as a rule it is on the generator. The emergency lamp (kerosene oil) is provided in case the electric light should fail.

The piping consists of cast-iron pipes, 100 and 80 mm (3.9 and 3.1 in.) in diameter; the cleaners are provided with shunt piping, so as to prevent disturbances in the flow of gas should a cleaner become clogged. By this means the flow of gas may be regulated as desired, and the cleaners connected in parallel.

German government regulations provide that there should be a water seal at each welding stand between the gas piping and the burner to prevent backfiring into the piping when the burner tube becomes clogged, as well as to prevent the oxygen from getting into the acetylene piping. Most of the accidents which have occurred in autogenous welding may be traced back to improperly designed or improperly kept water seals. In large plants, with an extensive system of piping there is the further danger that, with a defective water seal, the back firing may penetrate as far as the apparatus house or gasholder, and make trouble there. To prevent this, the Knappich safety water reservoir has been installed. It is shown in Fig. C, and its characteristic is that it is provided with an alarm whistle which acts automatically: (*a*) when the water level becomes too low; (*b*) when the welding pistol is clogged (the oxygen is then forced to flow through the alarm whistle, and produces the sound of alarm); (*c*) when, through some irregularity in the piping, air is admitted into it. This alarm whistle, which is set into motion by the kinetic energy of the oxygen under pressure, instantly and automatically indicates any error in the actions of the welder or attendants, so that they may be attended to before it is too late. One of the striking facts in connection with this plant (characteristic to a certain extent of acetylene installations generally) is the small attendance required. The present plant having an output of 300 to 600 cbm (10,594 to 21,188 cu. ft.) per day, or about five times as much as would be required for the lighting of a city of 5000 inhabitants, *has only one man for its attendance*. More than 50 welding burners are operated throughout the plants, from the smallest to the largest size, autogenous welding being used for the most varied purposes.

Electrical Case Carbonization of Iron and the Properties of the Product Obtained (*Electricheskaya tcementatciya jeleza i svoistva polaochenava prodookta*, I. A. Feshchenko-Chopovski. *Journal of the Russian Metallurgical Society* (in Russian), no. 3, 1913. p. 245, 10 pp., 3 figs. *de*). Garnier observed as early as 1883 that an electric current increases the velocity of the cementation process when the iron serves as a cathode, and retards it when the iron serves as an anode. In 1909, Prof. P. V. Ijevski, while investigating, in Russia, case carbonization of iron by means of illuminating gas, passed an electric current of low potential (about 15 volts) and large amperage (300 amperes) through the iron rod under test, in order to bring it up to the temperature required for case carbonization; the rod was in a glass tube, through which the gas flowed continuously at a given velocity. Data of these tests have never been published. The present author applied practically the same principle, but in a radically different form, which permitted him to effect the carbonization by means of a solid powder. In his first tests he used a so-called cryptol rheostat with a few pieces of soft iron placed in the cryptol mass.

The current meets a very large resistance while passing through the cryptol carbon, and in accordance with the Joule law, produces a large evolution of heat. In the author's tests a current of 5 to 8 amperes was passed at 250 volts during two to three hours, the iron pieces attaining their full temperature in less than half an hour. These tests have not given fully satisfactory results, due probably to faulty construction of the experimental furnace, and another type of furnace was worked out, in which the comparatively expensive cryptol was replaced by a mixture of retort coal and charcoal, with an addition of 40 per cent of barium carbonate (in some of the tests cryptol seems to have been used, however). The experimental furnace used is shown in Fig. 4, all the dimensions being given in millimeters (1 in. = 25.400 mm). A few bricks were laid flat on a wooden board, thus forming the bottom of the furnace, which was further covered by sand and protected by a sheet of asbestos. A few more bricks formed the walls of the furnace, leaving in the middle a rectangular space 7.4 in. by 6.4 in., 5 in. deep. As electrodes, iron bars, 6 in. by 2.4 in. by 0.33 in., were used, connected to copper wires as shown in the figure. Direct current of 250 volts was stepped down to 5 volts; the carbonized test pieces, iron bars 1.6 in. by 1 in. by 0.3 in., were placed in the space between the electrodes, two test pieces being generally used at a time, while as much as eight have been successfully handled at once, this being the maximum for a furnace of given dimensions. The distance between the electrodes was 3.2 in.

The carbonization proved to be even, and as deep as desired. Tests were made to determine the depth of the carbonized layer as a function of time and of temperature, and it was found (the original article contains full tables of tests) that, with a powder consisting of 60 per cent mixture of retort carbon and charcoal, and 40 per cent barium carbonate, and temperature of 970 deg. cent. (1778 deg. fahr.), the speed of cementation was 0.60 mm (0.0236 in. per hour). The functional relation between the temperature of the carbonization process and the speed of diffusion of carbon through the iron could not be established fully, and appears to follow some complex law. It has, however, been found to increase, as the temperature rose from 900 to 1000 deg. cent. (1652 to 1832 deg. fahr.). It has also been found that close packing of the powder near the test piece improved the results obtained, and also that the side of the piece towards the entering current was carbonized somewhat deeper than the opposite side, but this difference was slightly noticeable at high temperature and for long tests. Tests of hardness by the Brinell method have shown that the surface hardness increases with the thickness of the layer of case carbonization.

Materials of Construction

The Melting and Vaporization of Refractory Oxides (*Das Schmelzen und Verdampfen hochfeuerfester Oxyde*, wbo. *Tonindustrie-Zeitung*, vol. 37, no. 128, p. 1693, October 30, 1913. 1 p. *e*). The article contains data of tests on the melting point of refractory oxides by C. W. Canolt at the U. S. Bureau of Standards and Otto Ruff at the Technical High School, Danzig, Germany. Only the latter will be here reported. Oxides of the following elements were investigated: beryllium, magnesium, calcium, aluminum, yttrium, chromium and lanthanum, as well as zirconium dioxide, tin dioxide, titanium dioxide, cerium dioxide, thorium dioxide, niobium pentoxide, and tantalum pentoxide. It was found that only aluminum oxide had a melting point independent of the influence of the reducing action of the furnace atmosphere; beryllium oxide has been found to be nearly independent, but the relation of its reducibility to pressure and composition of the furnace atmosphere has not yet been definitely established; in the case of zirconium dioxide its composition before melting still needs investigation. For refractory containers beryllium and zirconium oxides appear to be the most suitable; aluminum oxide has too low a melting point for certain application, while magnesium oxide is good only where means have been taken to prevent its too rapid vaporization. The other oxides are easily reduced to carbides in the furnace atmosphere. The article contains a complete table of melting points of the oxides investigated, of which the following may be mentioned here (in nitrogen, first figure at atmospheric pressure, the other in partial vacuum, 10 to 30 mm.): beryllium oxide, BeO: 2200 and 2525 deg. cent. (3992 and 4577 deg. fahr.); magnesium oxide, MgO: 2500 and 2550 deg. cent. (4532 and 4622 deg. fahr.); aluminum oxide, AlO: 2010 and 2010 deg. cent. (3650 deg. fahr.).

Refrigeration

Increasing the Output of Cold of Carbon Dioxide Refrigerating Machines Particularly with High Condenser Pressures (*Beitrag zur Erhöhung der Kälteleistung und der Leistungsziffer von Kohlensäurekältemaschinen insbesondere bei hohen Kondensatordrücken*, R. Plank. *Zeits. für die gesamte Kälte-Industrie*, vol. 20, no. 10, p. 189, October 1913. 7 pp., 6 figs. *dtA*). Discussion of the thermodynamic principles of operation of compression refrigerating machines, and description of an improvement devised by the author, of particular importance for localities where cold cooling water is not easily available. The useful output of cold depends mainly, apart from the amount of heat of evaporation, on the state of the cold carrying medium in front of the regulating valve. The amount of moisture in the steam at entering the evaporator, and the output of cold secured are inversely proportional to the heat contents of the cold carrying medium in front of the regulating valve, and many efforts have been made to keep the latter as low as possible, e.g., by inserting liquid coolers working on the counter current principle, and securing a reduction of the cold carrying medium to nearly the temperature of the cooling water: for CO_2, especially in the neighborhood of the critical point, the gain thus obtained is quite substantial.

The heat content i is in general a function of temperature and pressure, but while the relation between heat content and temperature is simple, this is not so with pressure, where the relation is expressed by the following somewhat complicated differential equation:

$$\left(\frac{\partial i}{\partial p}\right)_t = -AT\left(\frac{\partial v}{\partial t}\right)_p + Au = AvT\left(\frac{1}{T} - \alpha\right)$$

where t or T denotes temperature, p pressure, v volume, $A = \frac{1}{427}$, mechanical heat equivalent, and $\alpha = \frac{1}{u}\left(\frac{\partial v}{\partial t}\right)_p$ thermal coefficient of expansion referred to the volume v. There may be several relations between α and $\frac{1}{T}$, the former being equal, smaller or larger than the latter; further α may be equal to zero or infinity.

For cold carrying media with a low lying critical temperature the state in front of the regulating valve is characterized by the relation $\alpha > \frac{1}{T}$ which applies both to the case of real gases and still more to liquids and vapors in the neighborhood of the critical point. When $\alpha > \frac{1}{T}\left(\frac{\partial i}{\partial p}\right)_t$ is negative, and therefore a rise in pressure reduces the heat contents. An increase in the output of cold may therefore be obtained simply by submitting the cold carrying medium, after its exit from the condenser, to a second isothermal compression; if this supplementary compression is adiabatic, the heat of compression must be removed in an additional small cooler, and in any case a gain in cold output is obtained, this gain being in most cases bought very cheaply since the work required for the

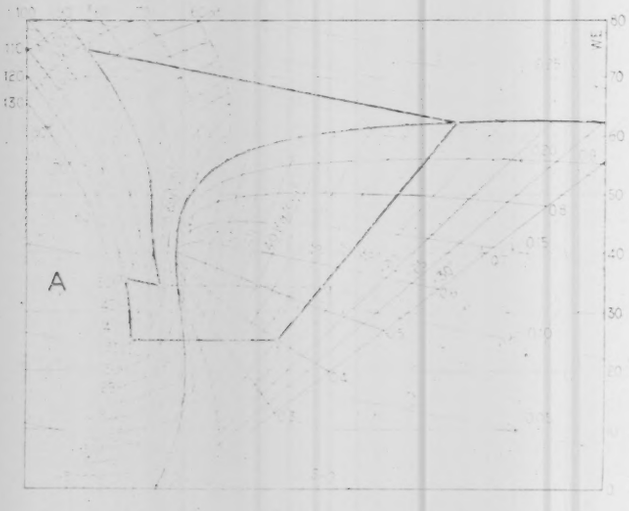


Fig. 5A JS Diagram, CO_2 Refrigerating Machine

compression of the CO_2 coming out of the condenser is very small, owing to the small volume of the gas so treated. The ratio of the cold output gained Q_o' to the compression work AL', or the efficiency $\epsilon' = \frac{Q_o'}{AL'}$ of the supplementary process, is, especially with high temperatures of the gas coming from the condenser, sometimes as much as four times higher than the efficiency of the original process $\epsilon = \frac{Q_o}{AL}$, and therefore, by the application of supplementary compression, not only the general, but also the specific output of cold is raised (a table in the original shows that this gain may be as high as 85 per cent, and has in several cases proved to be around 40 per cent).

For the practical application of the new process in the first instance is required a small pump that would compress the CO_2 to about 120-150 atmospheres. The compresison is practically adiabatic and the temperature of the gas rises therefore somewhat, 10 to 15 deg. cent. (18 to 27 deg. fahr.); this rise must be taken care of, which is done in a small cooler, in the form of a double wall pipe working on the counter-current principle. While by means of slow compression and efficient jacket cooling practically isothermic compression may be obtained, it is more practical to employ the above described combination of adiabatic compression and subsequent cooling.

To attain the greatest economy of the process, it is essential that the cold carrying medium be as thoroughly cooled

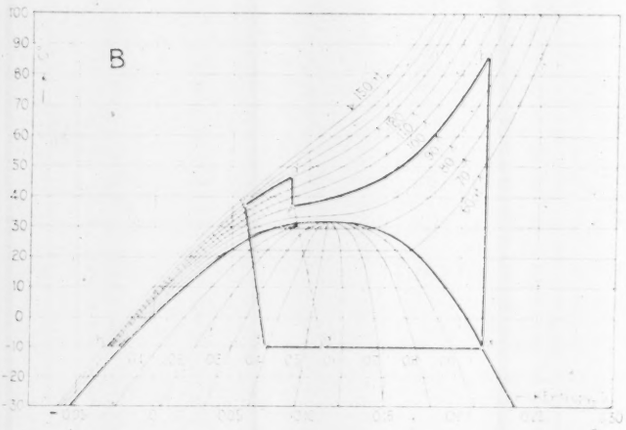


Fig. 5B TS Diagram, CO_2 Refrigerating Machine

as possible both before and after the supplementary compression. The power consumption for the supplementary compression is the smaller, the lower the temperature of the gas under compression. Under normal conditions the volume of the compression pump is 1/6 to 1/7 of that of the main compressor.

To illustrate the above description, both the usual and the modified processes are reproduced in the *JS*, *TS*, and *JP* diagrams in Fig. 5 A, B, C. The *JS* and *JP* diagrams are

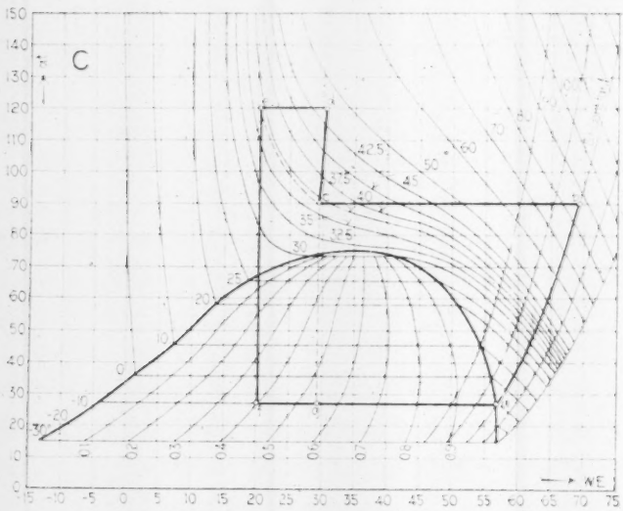


Fig. 5C JP Diagram, CO_2 Refrigerating Machine

particularly suitable for estimating the gain obtained, since these diagrams show both the power consumption of adiabatic compression in both cylinders and the power output, while *D* shows the gain in specific cold output when the new process is used. The usual process in refrigerating machines of this type occurs along the line *abcg* (Fig. 5 A), where *ab* represents the adiabatic compression of the gases coming out of the evaporator, *bc* the isobar in the condenser, *cg* the throttling curve in the regulating valve, and *ga* the isobar in the evaporator. The vertical distance between the points

g and *a* shows the available output of cold, while *ab* magnified five times represents the equivalent of the compressor work. The *modified process* follows the line *abcdefg* where *cd*, to the same scale as *ab*, shows the equivalent of the work of adiabatic compression of the pump, while *de* is the isobar of the supplementary cooler, and *ef* the displaced throttling curve. The vertical distance between the points *f* and *g* represents the gain in cold production (the points *c* and *e* are on the same isothermal).

In Fig. B both processes are plotted on the *TS* diagram. The area *abckga* is equivalent to the work of compression in the usual system, and *ga* may be considered as the measure of the cold output. For the new system the equivalent of the compression pump work is the area *cdehkc*, so that the total work of compression is given by the area of *abcdehkfa*, while the gain in cold output is characterized by *fg*. On the *JP* diagram the new process is shown in Fig. C: the horizontal distance between the points *a* and *b* is equivalent to the compressor work, and the horizontal distance between *c* and *d* to the work of supplementary compression

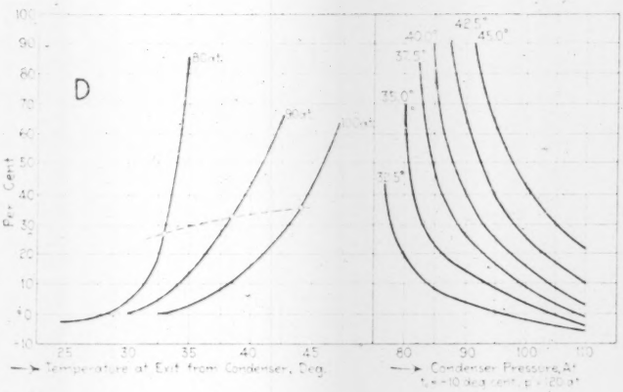


Fig. 5D Theoretical Cold Output, in Calories per Kg. of CO_2, at −10 Deg. Evaporation Temperature (*a*, Old System; *n*, New System)

(pump). The isobars *bc*, *de* and *fga* appear as straight horizontal lines, but the adiabatic curves *ab* and *cd* have lost the regularity which characterized them in Fig. A and B. The throttling processes in the regulating valve are represented by the vertical straight lines *ef* and *cg*, while the output of cold is shown in the old system by *ga*, and in the new by *fa*.

To determine the practical gain in the production of cold with the new system, all that is necessary is to know the temperature of CO_2 at coming out from the condenser when high condenser pressures are used. The gain may then be readily determined by means of Fig. 5 D and E. As has been shown by tests on actual machines, there is the following relation between condenser pressure and exit temperature: $p = 80$ atmospheres, $t = 33$ deg. cent. (91.4 deg. fahr); $p = 90$ atmospheres, $t = 38.5$ deg. cent. (101.3 deg. fahr.); $p = 100$ atmospheres, $t = 44$ deg. cent. (111.2 deg. fahr.). In Fig. D and E these temperatures are indicated by small circles and connected by a dotted line. Table 1 shows the respective gains for a temperature of evaporation of −10 deg. cent. (14 deg. fahr.), and a pressure in the auxiliary pump of $p' = 120$ atmospheres. These gains are still larger with higher pressures p', but could not be exactly computed on account of defects in the experimental plant.

The volume of the small auxiliary pump is to the volume of the main compressor in exactly the same ratio as the specific volume v of the CO_2 at pressure p and temperature t is to the specific volume v_o'' of dry saturated steam at the evaporation temperature t_o. With $t_o = -10$ deg. cent., $p = 90$ atmospheres, $t = 38.5$ deg. cent., v'' is 14.24 liters per kg. and v is 2.08 liters per kg. Therefore

$$\frac{v'}{v_o''} 100 = 15 \text{ per cent,}$$

which means that the volume of the auxiliary pump is about 15 per cent of that of the main compressor, both being assumed to be single acting. The author applied for a German patent for his invention.

TABLE 1 IMPROVEMENT IN COLD PRODUCTION WITH THE PLANK DEVICE

Condenser Pressure	Temperature of CO_2 at Exit from Condenser, Deg. Cent.	Gain in Output of Cold, Per Cent	Gain in Specific Output of Cold, Per Cent.
80	33	48	28
90	38.5	46	32
100	44	44	35

Steam Engineering

Blowing-off Boiler Deposits (*Abblasen des Kesselschlamms, Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 36, no. 46, p. 567, November 14, 1913. 12 pp., 2 figs. *dp*). The article states that the usual practice of letting the blow-off valve open for several minutes entails nothing but a useless waste of heat and water from the boiler. Merely a cone-shaped vortex is formed in the boiler deposit around the blow-off cock, and only the mud in that vortex is re-

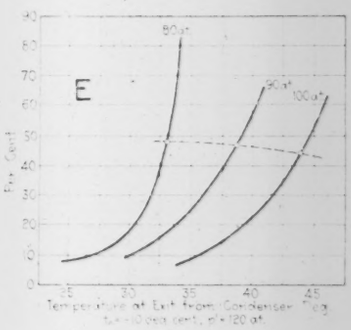


Fig. 5E Gain in Output of Cold

moved. To do that requires not more than 3 to 5 seconds, while for the rest of the time that the cock is opened, it is clear water that flows through, and it takes about 2 hours for the space in the neighborhood of the blow-off valve to fill in again. The best practice is therefore to open the blow-off valve every 2 or 3 hours for a few seconds. If the usual hand wheel blow-off valve is used, however, it would be hardly advisable to let the boiler attendant blow off the boiler so often and for such a short time, and the *Gestra valve* (Fig. 6) has therefore been arranged in such a manner that the fireman can from his stand operate it by a chain or foot treadle (Fig. A). It is provided with two stop cones (Fig. B). The main cone *a* with its seat may be re-

moved for repair purposes; the safety cone *b* will still remain automatically closed; the double closing arrangement is also effective in preventing possible leaks.

INCREASING FIRETUBE BOILERS (*Vergrösserung von Flammrohrkesseln*, Pradel. *Braunkohle*, vol. 12, no. 32, p. 547, November 7, 1913. 3 pp., 4 figs. *d*). It is often desirable to increase the output of a fire-tube boiler without either increasing the space occupied by the boiler, or going to great expense. This can be done by the so-called Eimert battery manufactured by a German concern, and consisting

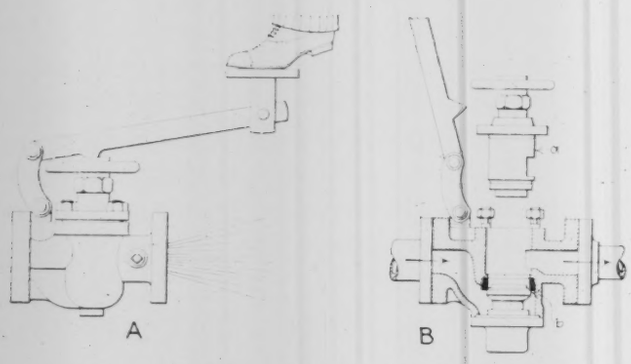


FIG. 6 GESTRA VALVE FOR BLOWING-OFF BOILER DEPOSITS

of seamless Mannesmann pipes of special steel stayed, by seamless welding, in a header of appropriate shape and size. In Fig. 7 is shown such an Eimert battery constructed in a side flue of a boiler. This arrangement provides the fire-tube boiler with all the advantages of a water-tube boiler in respect to the speed with which steam can be raised. The action of the battery of tubes is based essentially on the fact that the hot gases are forced to play around the tubes all along their length, and, by a proper distribution of joints, an extremely rapid and vivid circulation of water is secured, such as is generally lacking in a fire-tube boiler. The battery, which is inserted into the flue on rollers in such a manner that it slopes forward, is connected to the lowest part of the water space in front, and to the highest in the rear; further, the rear steam collector is connected directly with the steam space in the main boiler. Tests have shown that with this arrangement an increase in steam generation as high as 40 per cent has been actually obtained. The article gives data of tests with and without the Eimert battery, and shows that the efficiency of the plant before the additional installation was 50.52 per cent, and became 75.30 after the Eimert battery was installed; water evaporated per hour rose from 2050 kg. (4510 lb.) to 2300 kg. (5060 lb.), the rate of evaporation having changed from 25.59 to 28.71 kg. per qm-hr. (from 5.27 to 5.91 lb. per sq. ft-hr). The losses in both cases are given as follows: smokestack: before the installation of the battery 20.45 per cent, after —11.95 per cent; radiations, residues, etc.: before —29.03 per cent, after —12.75 per cent.

FRICTION OF GASES AGAINST THE WALLS OF BRICK PASSAGES. (*Trenye gazof o stenki kirpichnikh kanalof*, V. A. Mojaroff. *Journal of the Russian Metallurgical Society*, no. 3, 1913, p. 335, 35 pp., 2 figs. *mpA*). The author, in connection with some repairs to a blast furnace installation, had to determine how much hotter a blast a Massick and Crookes stove will give than a similar Cowper stove, all other conditions being equal. To do this, the author had, among other things, to determine the friction of gases against the walls of brick passages, a problem with which the builder of smokestacks, brick arches, etc., has also often to occupy himself. Guided by Professor Grum-Grzimailo's theory of the application of methods of hydraulics to the calculation of metallurgical furnaces, the author derived a general formula for the resistance to the flow of gases through brick-lined passages, and determined the coefficient of friction of the gases for this case.

With the same area of cross-section, the passages through which a gas flows may have very different shapes, from that of a circle to a long narrow slot; hence, the ratio of perimeter of passage to its cross-section may be variable. Since the friction of a gas against the walls of a passage is proportional to its perimeter, the amount of work spent to overcome this friction, is not equal in the case of several passages with equal cross-sections, but unequal perimeters: the ratios of loss of head due to friction in such passages is proportional to the ratios of their perimeters. Since of all sections of equal areas, the circle has the minimum perimeter, the perimeter of a circle and the work of forcing the gas through a passage of circular cross-section may be taken as units; then for all other sections of equal areas their perimeters and loss of head due to friction may be expressed as $\frac{S}{C_1}$ or as $\frac{S}{\pi D_1}$ where S is the actual perimeter of a section of the gas passage, C_1 the circumference of a circle of area equal to that of the actual cross-section of the passage, and D_1 the diameter of this circle.

The circumference of a circle is proportional to its diameter, the area to D^2; the friction loss in the case of a circular passage is proportional to the circumference of the passage; the volume of the gas passing in unit time to the area, and since the energy of the gas is a function of its quantity, it is evident that that part of its energy which is lost to overcome the friction against the walls of the passage, and the

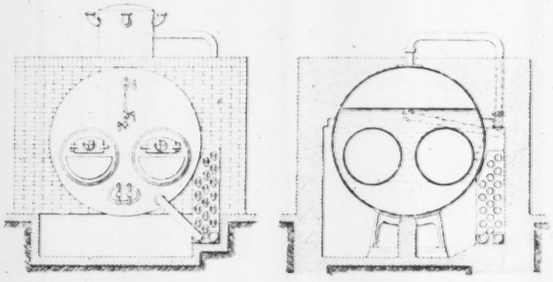


FIG. 7 FIRETUBE BOILER WITH EIMERT BATTERY

corresponding loss of head, will vary as the ratio of the diameter to the area of the passage, all other conditions being the same, or as $\frac{4}{D_1}$. In other words, in the case of the flow of gas through circular passages, the loss of energy due to friction is inversely proportional to the diameter of the passage. By combining this formula with the one preceding, it is seen that, whatsoever the shape and free area of cross-section of the passage may be, the loss of en-

ergy in the gas due to friction is proportional to the expression

$$\frac{S}{\pi D_1} \frac{4}{D_1} = \frac{S}{\frac{\pi D_1}{4}} = \frac{S}{\omega}$$

where ω is the area of the free section of the passage. For a given length of flow of gas L the loss of energy is also proportional to L.

The work of friction of gas against the walls of the passage and the corresponding loss of head vary with the amount of gas flowing, and are therefore a function of the average velocity of flow of gas through the passage, and since the pressure of the gas varies also with the change of temperature, the friction loss must be a function of the pressure or density of the gas, or, combining the two, $f(v_t, p_t)$. The exact expression of this function is unknown.

In hydraulics it is usually assumed that frictional resistance is a linear function of the velocity of flow, and, in the absence of proofs to the contrary, the same may be done in the case of flow of gas. The coefficient which should be added to the expression $\frac{SL}{\omega} v_t p_t$ depends on the physical properties of the walls of gas passages, and, in the case under investigation, may be called the coefficient of friction of a gas against brick walls; it will be denoted here by the letter m. Summing up, the loss of head due to friction, expressed in millimeters of water, and denoted by γ, may be expressed as

$$\gamma = m \frac{SL}{\omega} v_t P_t$$

where m is the coefficient of friction of gas against brick walls; S perimeter of the passage in meters; ω area of section of the passage in square meters; L length of the passage through which the flow is measured, in meters; v_t velocity of flow of gas in the passage in meters, at t deg. cent.; p_t weight of 1 cu. m. of gas in kilograms, at an average temperature of t deg. cent. which the gas has in the investigated part of the passage.

The same formula may be expressed as $\gamma = m \frac{SL}{\omega^2} Q_o p_o$, where Q_o is the volume of the gas flowing through the passage per second, and p_o the weight of 1 cu. m. of gas at 0 deg. cent. and 760 mm. pressure.

The constant m which is a function of the physical properties of the brick clad surface of the passage is the one that must in all cases be determined in order to make possible the calculation of the energy loss due to friction, and the author shows that m is the head in millimeters of water corresponding to the loss of energy due to friction, in 1 second, of air at 0 deg. fahr. and 760 mm. pressure, moving with a velocity of 1m/sec. (3.28 ft. per sec.) through a brick lined passage the area of the cross-section of which satisfies the equation: $\frac{\omega}{S} = 1.293$. If the passage is circular, $\frac{\omega}{S} = \frac{D}{4} = 1.293$, and hence $D = 5.172$ m. $= 16.967$ ft. In the case which was specially investigated by the author, m was found to be equal to 0.016, all the other units being metric, as stated above, and it appears that this coefficient may be used for general purposes of practical calculations (it was determined both experimentally, and by calculation).

Concerning the Bone-Schnabel Boilers (*Zur Beurteilung der Bone-Schnabel-Kessel*, G. Neumann. *Stahl und Eisen*, vol. 33, no. 47, p. 1929, November 20, 1913. 7 pp., 2 figs. *et*). The author accepts neither the theory of explosive waves of Jüptner, nor Bone's theory of catalyzing surfaces, nor the electrone theory of Carleton Ellis. The actual combustion in the tube ceases 20 cm (7.8 in.) from the front opening, the rest of the tube serving simply as a heating space; in the preheater there is likewise no actual combustion, but heat transference only. At the same time it has been proved experimentally that it does not pay to have the tube filled only as far as actual combustion occurs. This fact, as well as the further fact that the distribution of heat in the surface combustion boiler is very like that in an ordinary boiler, make all of the above theories untenable, according to the author's opinion. As compared with other boilers, the Bone-Schnabel has the following particulars: (*a*) the presence of intentionally placed resistances in the path of the gas stream against which the gas must constantly impinge; (*b*) introduction into the stream of the gases of combustion of a second indirectly acting heating surface, namely, of the heat radiating surface of the pieces of porous material lying on the outside; (*c*) increase in the velocity of the flow of gases through decrease of the free section of the tube, caused by the introduction of the porous bodies. As the most important property of these boilers may be named their high heat absorption per unit of heating area, as well as the high specific output combined with a low temperature of flue gases; attention may also be called to the completeness of combustion in the new type of boilers.

As regards filling the heating tubes in the zone of combustion with porous granules, it certainly has in many cases a beneficial effect on the completeness of combustion. Most fuels, solid as well as liquid and gaseous, either contain initially or develop in the gasification preceding the combustion, a number of heavy hydrocarbons which in ordinary systems of firing leads to incomplete combustion through formation of soot; in order that these hydrocarbons be fully burned, the temperature of the combustion must be so high as to cause their decomposition, a condition which is but seldom satisfied in the usual practice, but actually followed out in the Bone-Schnabel boiler. Owing to the fact that the heating tubes are filled with porous granules of a material poorly conducting heat, these tubes contain numerous hollow spaces protected, by the poor heat conductivity of the material, from radiation losses to the tube walls, and thereby permit the gases to burn at a high temperature, in thorough mixture with air, and therefore without soot formation. In addition to this, the thorough mixture of gas and air previous to the entrance of the combustible material into the combustion chamber very materially raises the velocity of combustion as well as its temperature, especially when the excess of air is as low as appears to have been used in the tests described. Further, since the hollow spaces in the porous elements in the tubes do not form consecutively connected in one direction passages, the gases are compelled to impinge from time to time against the granules and to produce thereby violent eddy motion, which, in its turn, forces the particles of the mixture which have reached the zone of combustion first, to deflect towards the colder walls of the tube, and to drive inside, into the zone of combustion, the outer cold particles of gas. There occurs therefore,

first, a thorough and uniform combustion of the entire gas mass, and, second, a constant giving-up of heat from the gas particles to the tube walls. As regards the porosity of the granules, the author, in the case of the Bone-Schnabel boiler firing, does not attach to it much importance. The mixing of the air and gas may very well take place between the granules themselves, and not in their pores, which, if they were there initially, would soon be clogged up when certain kinds of gases are used (e.g., blast-furnace gas).

According to published data, the specific evaporation of the Bone-Schnabel boiler is exceptionally high, being 80 to 150 kg/qm (16.4 to 30.75 lb. per sq. ft.) as compared with the rate of evaporation of 40 kg/qm (8.2 lb. per sq. ft.) of the high duty boiler with ordinary firing (it must be, however, borne in mind that the Bone-Schnabel boiler delivers only saturated steam, while the rate of evaporation for the high duty modern boiler refers to superheated steam). In addition to the high rate of evaporation, the Bone-Schnabel boiler is peculiar for the low temperature of its exhaust gases.

Now, since it has been found that the evaporation in the Bone-Schnabel boiler is distributed in approximately the same way as in the ordinary boiler, it appears that all the parts of the heating surface, and not the zone of combustion alone, contribute equally to the larger heat transference, and it becomes of interest to establish the causes that permit the Bone-Schnabel boiler to generate twice to thrice as much steam as the usual high duty modern boiler. In the first place it must be remembered in this connection that in addition to the direct heating surface of the heating tube there is also an indirectly acting heating surface formed by the faces of the granules directed towards the walls of the heating tubes. The granules lying in the inner parts of the tube and protected from radiation losses, must have the temperature of the gases of combustion, while the faces of the granules directed towards the tube walls will have a temperature between that of the gases of combustion and that of the walls, the temperature of the latter granules being so high that the heat transferred to the indirect heating surface from the gases of combustion should be equal to that radiated from the granules to the tube walls. While the temperature of the granules forming the indirect heating surface, and the dimensions of the latter referred to the direct heating surface, cannot yet, through lack of sufficient data, be determined analytically, the author assumes that the value of the indirect heating surface is equal to one-half of that of the direct heating surface of equal area, and expresses therefore the total heating surface as

$$H_g = 1.5H_d$$

where H_d is the direct heating surface (the heating surface of the tubes).

Of still higher significance is, however, the fact that, owing to the contraction of the free section of the tubes as compared with that in ordinary types of boilers, the velocity of flow of the gases of combustion is many times higher. Nusselt and others have shown long ago that for an equal head of temperature between the heating surface and the gases of combustion, the heat transmission per unit of time and area is proportional to the velocity of the flow of gas. Thus Nusselt has shown that when the velocity of the flow of gas has been increased from 11.89 m/sec. to 27.2 m/sec., the heat transmission, per sq.m. of surface hour and deg. cent. of temperature difference, rose from 46.9 to 91.7 WE (185.7 to 363.1 B.t.u.), or about doubled. While these figures, which were derived for comparatively low temperatures, cannot be without further tests applied to the case of the far higher temperatures with which we have to deal in this case, it must be also borne in mind that the velocity of gases in the Bone-Schnabel boiler tubes is considerably in excess of 27.2 m/sec. (89.2 ft. per sec.). Besides, the temperature of combustion, and therefore also the average difference in temperature between the heating tubes and the gases of combustion is much higher in the type of boiler under consideration than in the usual boilers, and this again materially affects the rate of evaporation. Recapitulating all the above, one may assume that the higher gas velocity and difference in temperature at least doubles the heat transference to the heating surface, and since the heating surface itself, through the addition of the indirect heating surface, is one and a half times as large as in the ordinary boiler, the output of the Bone-Schnabel boiler, as compared with the ordinary type, must be $1.5 \times 2 = 3$ times as large, and the above considerations explain not only the higher output of the boiler, but also the lower temperature of its flue gases.

A Suggested Improvement in the Construction of the Surface Combustion Boiler. The great objection to the Bone-Schnabel boiler lies in the large amount of power consumed by the draft fan, and the author raises the question as to whether filling the tube with porous granules is really the best way to raise the efficiency of the boiler. In his opinion, in the Bone-Schnabel boiler not enough attention is paid to the distinction between what the zone of combustion and the heating zone proper have to do. The author has found that, in order to increase the specific heat absorption, it is of advantage to use high velocities of the flow of gas, as well as to build-in another indirectly acting heating surface which would take up by contact the heat from the gases acting on the direct heating surface, and transfer it, by radiation, to the tube walls. This part of the problem is only imperfectly solved in the Bone-Schnabel boiler, since, in addition to conditions which require an excessive amount of power at the draft fans, a large amount of the heating material is cut off from the tube walls by poor heat conductors, and thus prevented from participating in the transference of heat. Further, even while through the above described eddy action, most of the gases do reach, at one time or another, the heating surface of the tubes, the fact that the contact between the gas and the heating tubes is not continuous, is not of advantage, and the boiler would have shown a much lower efficiency if it were not for the fact that the velocity of the gas along the tube surface is greater than in the other parts of the tube, and that therefore a larger part of the gas flows in direct contact with the tube wall. Instead, therefore, of shaping the tube as shown in Fig. 8 A, which is the Bone-Schnabel construction, the author recommends the design shown in Fig. B, with solid elements placed in the tube; by this means the free section is reduced, the velocity of the gases of combustion considerably increased and a second heating surface created, acting indirectly, by radiation. With this kind of tubes the partial vacuum required at the boiler end is only a small part of that necessary with the Bone-Schnabel tubes (which means a saving in power at the fan), while the cleaning of the tubes is made much easier, a fact of importance especially when working with blast furnace gases.

TABLE 2 BONE-SCHNABEL BOILER WITH COKE-OVEN GAS FIRING

Coke oven gas, heating value, 3597 WE per cbm. = 403 B.t.u. per cu. ft.	Per Cent		
CO_2	0.025	0.025 cbm. CO_2	0.390 cbm. CO_2
CO	0.065	0.065 cbm. CO_2	1.040 cbm. H_2O
CH_4	0.260	0.260 cbm. CO_2 0.520 cbm. H_2O	4.373 cbm. N_2+O_2
C_2H_4	0.020	0.040 cbm. H_2O 0.040 cbm. CO_2	5.803 cbm. (1.61 cbm. of flue gases per 1000 WE = 14.5 cu. ft. of flue gases per 1000 B.t.u.)
H_2	0.480	0.480 cbm. H_2O	
O_2	0.037	0.037 cbm. O_2	
N_2	0.113	0.113 cbm. N_2	
		0.213 cbm. O_2	
	100	4.010 cbm. N_2	

CO_2 $0.390 \times 0.395 = 0.154$
H_2O $1.040 \times 0.343 = 0.357$
N_2+O_2 $4.373 \times 0.284 = 1.242$

Heat content of flue gases $= 1.753 \times 80 =$
$140 \text{ WE} = \frac{140}{3597} = 3.9$ per cent

Flue gas losses	3.9 per cent
Radiation and conduction	2.5 per cent
"Gross" efficiency	93.6 per cent
	100 per cent

"Gross" efficiency	93.6 per cent
Gas loss to driving the fan	5.2 per cent
"Thermo-technical" efficiency	88.4 per cent

Boiler output 3000 kg. (6600 lb.) of steam at 100 deg. cent. from water at 0 deg. cent.

Steam generation per cbm. of gas $= \frac{3597 \times 0.936}{637} = 5.29$ kg. (= 0.329 lb. of steam per 1 cu. ft. of gas).

Gas consumption per hour $= \frac{3000}{5.29} = 567$ cbm. = 20,015.1 cu. ft.

Flue gases per hour $= 567 \times 5.8 = 3290$ cbm. = 116,140 cu. ft.

Flue gases per second $= \frac{3290}{3600} = 0.91$ cbm. (15 deg. cent) = 32.3 cu. ft. (59 deg. fahr.).

Fan power consumption $= \frac{1.17 \times 550 \times 10{,}000}{75 \times 0.5 \times 9450} = 18.2$ h.p.

Steam consumption at the fan $= 18.2 \times 9 = 164$ kg./hr. = 360 lb./hr. $= \frac{164}{3000} = 5.5$ per cent.

Corresponding gas loss for the fan $= 5.5 \times 0.936 = 5.2$ per cent.

TABLE 3 BONE-SCHNABEL BOILER WITH BLAST FURNACE GAS FIRING

1 cbm. blast-furnace gas, heating value 861 WE (96.4 B.t.u. per cu. ft.)	Per Cent		
CO_2	0.114	0.114 cbm. CO_2	0.388 CO_2
CO	0.274	0.274 cbm. CO_2	0.040 H_2O
H_2	0.040	0.040 cbm. H_2O	1.348 N_2+O_2
N_2	0.572	0.572 cbm. N_2	1.776 cbm. (2.06 cbm. of flue gases per 1000 WE = 18 cu. ft. per 1000 B.t.u.).
		0.737 cbm. N_2	
	100	0.039 cbm. O_2	

CO_2 $0.388 \times 0.395 = 0.153$
H_2O $0.040 \times 0.343 = 0.013$
N_2+O_2 $1.348 \times 0.284 = 0.382$

Heat content of flue gases $= 0.548 \times 80 =$
$44 \text{ WE} = \frac{44}{861} = 5.1$ per cent

Flue gas losses	5.1 per cent
Radiation and conduction losses	−2.5 per cent
"Gross" efficiency	92.4 per cent

"Gross" efficiency	92.4 per cent
Gas loss to driving the fan	7.1 per cent
"Thermo-technical" efficiency	85.3 per cent

Boiler output 3000 kg. (6600 lb.) of steam at 100 deg. cent. from water at 0 deg. cent.

Steam generation per cbm. of gas $= \frac{861 \times 0.924}{637} = 1.25$ kg. (= 0.078 lb. of steam per 1 cu. ft. of gas).

Gas consumption per hour $= \frac{3000}{1.25} = 2400$ cbm. = 84,800 cu. ft.

Flue gases per hour $= 2400 \times 1.776 = 4260$ cbm. = 150,000 cu. ft.

Power consumption at the fan $= \frac{1.51 \times 600 \times 10{,}000}{75 \times 0.5 \times 9400} = 25.7$ h.p.

Steam consumption at the fan $= 25.7 \times 9 = 231$ kg. = 508.2 lb./hr. $= \frac{231}{3000} = 7.7$ per cent.

Corresponding gas loss for the fan $= 7.7 \times 0.924 = 7.1$ per cent.

The author expresses some skepticism both as to the published data concerning the efficiency of the Bone-Schnabel boiler (90 and even as high as 92.5 per cent), and the indicated exceptionally low values for the excess of air used (2 to as low as 0.5 per cent). As regards the latter, the author does not believe that the boiler can work economically with so low an excess of air. The heating value and chemical composition of the gas vary from time to time, and at the same time even with the best regulating devices it is hardly possible to keep absolutely constant at each second the ratio between air and gas admitted. The variation in the chemical composition of the gas is of great importance inasfar as it affects the excess of air requirements. Assume, e.g., that in coke oven gas the percentage of hydrogen increased at the cost of that of nitrogen and carbon dioxide; to produce complete combustion, the amount of air present would have to be increased, and if this does not take place (and it will not, since the partial vacuum behind the air regulating valve does not change), there will be a certain amount of methane and hydrogen which will escape unconsumed (unless there is a large excess of air present). The losses in this case will be particularly large because, first, the volume of the gas flowing will increase on account of the

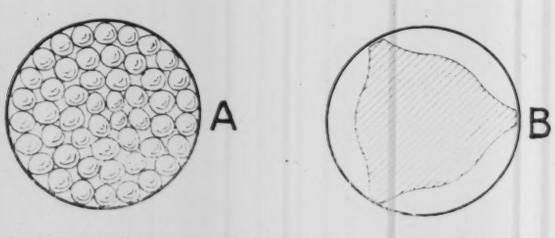


FIG. 8 SURFACE COMBUSTION BOILER, HEATING TUBES, BONE-SCHNABEL AND NEUMANN TYPES

reduction of its specific weight, and, second, as often happens in practice, this condition may coincide with a rise of pressure in the gas mains. The Bone-Schnabel boiler requires therefore approximately the same excess of air, say 15 to 25 per cent, that other boilers do.

Tables 2 to 6 have been calculated by the author on the following assumptions. The resistance which the exhaust fan has to overcome has been assumed to be equal to 550 mm of water in the case of a coke oven gas boiler and 600 mm for a blast furnace boiler (an excess of air of 25 per cent is assumed). The heating values and specific weights of the gases are taken from the German engineering handbook "Hütte"; the moisture in the air and gas is neglected throughout. In order to be on the safe side, a loss of 2.5 per cent due to unconsumed gas residue is assumed for the case of an ordinary boiler heated by coke oven gas. Table 6 shows that thermally the ordinary boiler is equivalent to the Bone-Schnabel boiler with blast furnace gas fuel, and slightly superior to it with coke oven gas as a fuel, this notwithstanding the fact that the values for the surface combustion boiler are the highest possible with an installation and draft fan of great perfection, while the ordinary type of boiler may be improved, e.g., by elimination, in the case of coke oven gas fired boiler, of the 2.5 per cent loss through incomplete combustion of the gas. The situation is still less favorable to the Bone-Schnabel boiler when the old and new types of boilers are compared from the standpoint of economic efficiency. Up to the present time the first cost of the Bone-Schnabel boiler has been somewhat higher than that of a corresponding water tube boiler, and, in addition to that, the new boiler has been made so far only in comparatively small units, is difficult to regulate with respect to load and does not produce directly superheated steam; if auxiliary appliances for making the latter are introduced, then the slight advantage in space-demand, as compared with the water tube boiler, is entirely lost. As regards safety of operation, the author objects to the high specific duty of the heating surface, especially with regard to water circulation, and the inaccessibility of the heating surface in contact with water. The final extraction of heat from the flue gases appear to be more economical when

TABLE 4 ORDINARY TYPE OF BOILER WITH COKE OVEN GAS FIRING AS IN TABLE 2

	Per Cent
Flue gas losses 1753 x 160 281 WE	7.8
Radiation and conduction	3.5
Unconsumed gas residues	2.5
Steam consumption for suction draft	1.0
"Thermo-technical" efficiency	85.2
	100

TABLE 5 ORDINARY TYPE OF BOILER WITH BLAST FURNACE GAS FIRING AS IN TABLE 3

	Per Cent
Flue gas losses 0.548 x 160 88 WE	10.2
Radiation and conduction	3.5
Steam consumption for suction draft	1.0
Efficiency	85.3
	100

TABLE 6 "THERMO-TECHNICAL" EFFICIENCY WITH DIFFERENT AMOUNTS OF EXCESS AIR

(in per cent)

	Blast Furnace Gas		Coke Oven Gas	
Excess of air	25	15	25	15
Ordinary boiler	85.3	85.7	85.2	85.8
Bone-Schnabel boiler	85.3	86.2	88.4	89.1
Difference in favor of the Bone-Schnabel boiler	..	0.5	3.2	3.3

done in the preheater than in the boiler, so that in this respect too the new boiler does not offer any particular advantages. Even though many of these objections may be obviated by future improvements, the author believes, from his theoretical considerations, that the surface combustion is not likely to drive out of business the modern well kept boiler plant.

CONCERNING THE TAYLOR SYSTEM (*À propos du système Taylor*, Ch. Frémont. *La Technique moderne*, vol. 7, no. 9, p. 301, November 1, 1913. 7 pp., 10 figs. *dh*). From historical references quoted by the author it appears that careful tests in time setting have been made as far back as the seventeenth century, while Bélidor, an engineer who published a book on hydraulic engineering in the middle of the eighteenth century, gave in his work a time rate for driving piles exact to seconds, having, e.g., determined that to drive a pile 16 ft. deep into a certain kind of ground will require 185 min. 34 sec. Dynamometers to measure the effort of a workman have been built by Leonardo da Vinci, and, of a more elaborate type, in the eighteenth century. As regards the present application of the Taylor system in

France, the author expresses the belief that the difficulty lies in the lack of engineers thoroughly trained in their specialty, the encyclopedic character of French engineering education being unsuitable for the formation of engineers possessing a complete knowledge of every detail of the operation, such as the application of the Taylor system requires.

ENGINEERING SOCIETIES

AMERICAN GAS INSTITUTE

Annual Meeting, October 1913

Design of Surface Combustion Apparatus, Charles Edward Lucke.

The paper deals with the development by the author of practical gas-burning apparatus to utilize the process known as *surface combustion*. The new process involves the thorough pre-mixture of the air and gas in the proportions necessary to supply exactly the required amount of oxygen for the combustion reaction. This premixture of air and gas in combining proportions at once removes two important sources of loss in combustion: that due to excess

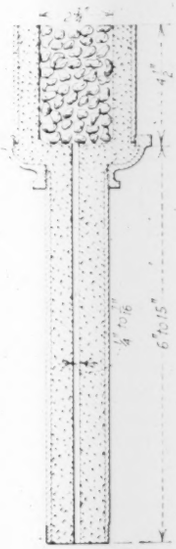


Fig. 9 Type of Burner Used for Determining Size and Length of Feed Holes

air and that due to incomplete combustion. Another advantage follows, also, of no less importance in that it is possible to produce a large part of the heat of combustion in radiant form, the superior advantage of which has long been recognized by physicists. Since the air is supplied in correct proportions initially, the combustion is entirely independent of the atmosphere into which the products discharge and can be carried on behind layers of solid granules, in the crevices between them, behind plates of any convenient form, or with any similar devices, which thus attain the temperature of the products of combustion and radiate heat.

Various problems are encountered in attempting to design apparatus to accomplish surface combustion. Under the conditions the combustion is instantaneous and almost explosive with the result that the flame tends to travel instantly to the point of pre-mixture of the air and gas and thus away from the point of heat application. As a basic principle, the localization of the combustion zone must be attained by providing a means for delivering the mixture of air and gas to the desired combustion point at a rate higher than the normal speed of flame propagation in the mixture. This is accomplished by using small tubes or holes for the delivery of the mixture to the fire zone at a high velocity and an enlargement of the area near the fire zone in which the velocity of the mixture drops to that of the flame propagation.

The line of development has been from the simpler apparatus consisting of narrow tubular passages with conical expanding openings at the ends for the flame zone, to more

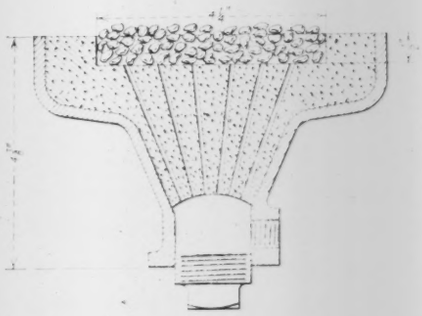


Fig. 10 First Design of Burner with Multiple Feed Holes in which Location of Combustion is controlled

elaborate devices embracing means for more positively localizing the zone of combustion in the form of baffles of such formation as to assist the spreading of the mixture streams beyond the point of high velocity supply; these take the form of refractory granules so arranged in the expanding combustion zone as to counteract the natural tendency of gas jets to remain intact and resist sidewise expansion, and by means of this combination, it is possible to secure a very

Fig. 11 Top View of First Successful Cook Stove Burner with Multiple Orifices

high degree of incandescence, higher in fact than is possible by any other means using air and the same gas.

The investigations show that the baffling material should consist of pieces of not less than about 1/8 in. diameter and that the feed orifice should be in refractory material since if metal is used there is a tendency to heat and pre-ignition may occur. The feed passages should be of uniform bore and of a diameter corresponding to their length. For instance, a 1/16-in. feed hole 1½ in. long was operated indefinitely with a supply pressure of the mixture as low as 0.2 in. of water; and similarly a ¼-in. hole 6 in. long could

be operated indefinitely with a supply pressure of the mixture at 1-in. water pressure. A 7/16-in. feed hole allowed the flame to flash back to the mixing chamber with a supply pressure of 1½ in. water pressure, even when increased in length to 15 in.

The second important problem is the control of heat generation so that the burning mixture may be distributed over surfaces as large or small as demanded and of the required degree of incandescence. In an effort to determine the maximum possible rate of combustion over a given area, a burner with an area of surface of only 6 sq. in., Fig. 9, was tested with different combinations of feed holes and supply pressure with remarkable results; beginning with a single feed hole 5/16 in. in diameter, the trials were carried to a combination of four feed holes and a supply pressure of 10½ in. of water, which corresponded to a rate of combustion of 2460 cu. ft. of gas per sq. ft. of bed per hour, with a corresponding calorific value of 1,584,000 B.t.u. per hour per sq. ft. Even with this there was no indication that the limit of rate had been reached, but this rate was so high as to give trouble with the available refractory materials at hand. The conclusion was that rates of combustion higher than have ever been known before are easily obtainable, and higher, in fact, than any refractory material in common use can resist.

A greater difficulty, however, was experienced in determining the form of apparatus and conditions necessary to secure low rates of combustion over a bed with uniform incandescence at the surface. The lower the supply pressure of the feed mixture the closer the combustion surface will locate to the feed hole with corresponding tendency of the flame to flash back to the mixing box.

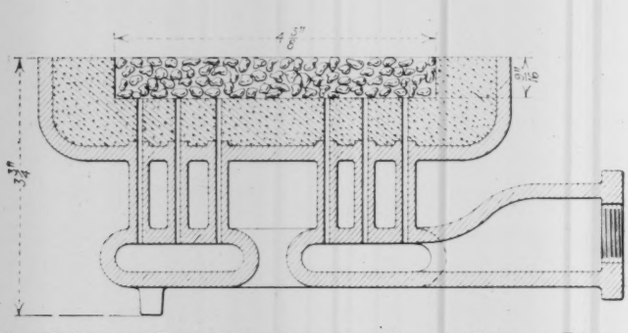


Fig. 12 Improved Form of Burner with Feed Holes so Formed as Effectively to Prevent Back Heating

An arrangement of multiple orifices was finally adopted with feed tubes extending through a considerable depth of the refractory lining of the hearth and so spaced as to give the heat distribution desired at the available pressure. Back heating was controlled in the burner of this design by arranging the feed holes through the refractory lining so that they radiate from practically a center at the feed box to points of even distribution over the fire bed and such a disposal of the burner casing around the lining as to facilitate the radiation of heat from the lining at these points to the atmosphere, Figs. 10 and 11.

From the large number of burners that were built and subjected to practical tests, a design was finally evolved which differs from that above described only in that the multiple feed holes pass down from the lining into and through separate legs or stems formed in the base of the iron burner casting, from which free radiation of heat to the atmosphere is possible. This form of burner, Figs. 12 and 13, provides sufficient cooling of the feed holes to render a flash-back practically impossible.

The third important division of the problem is the matter of control and adjustment of radiating surface, namely, the provision of means for adjusting the rate of combustion of any burner from minimum to maximum, and to operate safely and surely with one adjustment no matter what the

Fig. 13 View of Improved Burner Showing Arrangement of Individual Stems to Effect Positive Cooling of Feed Holes

previous adjustment or the time of operation. The range of control of rate of combustion depends primarily on the size of feed holes and on the effectiveness of cooling them by radiation of heat from the metal casing. With holes 1/16 in. in diameter in cook stove top burners, broilers and room heaters, it was found that they can be safely operated at 0.2 to 0.3 in. pressure and that at least as great a range of adjustment can be obtained as is possible with the Bunsen burners of the ordinary form without flash back. The time of heating is likewise within control by varying the thickness of the bed of refractory material.

The experiments led to the development of the successful form of quick heating top burner which becomes incandescent at the normal rate of combustion in about half a minute, and it is doubtful whether this time can be reduced, since a limited amount of heat storage is necessary to resist the effect of spilling water or grease upon it, and for intermittent work such as heating laundry irons, which may absorb heat for a time faster than generated. The burner is formed by countersinking the outlet side of the 1/16-in. feed holes to ½ in. and filling the conical holes thus formed with silica in sizes from 5/32 to ⅛ in. and aso covering the entire hearth to a depth of about ¼ in. as indicated in Fig. 14.

A fourth problem relates to the development of the necessary auxiliary apparatus for operating the burners, such as supply cocks, pressure-regulating valves, etc. For the surface combustion burner, two valves are necessary for properly adjusting the ratio of air to gas, and as it is undesirable to place the control of two such valves in the hands of inexperienced operators, a double ported mixing valve has been developed as is shown in Fig. 15, in which is provided a single handle that controls both gas and air pressure supplies, and also means for the adjustment of the air opening for proper proportionment of the ratio of air to gas. This latter is accomplished by the hand wheel at the bottom of the valve which adjusts the air plug axially and so varies the opening of the air port.

An essential for satisfactory working of a double ported

cock of this type is equality of pressure of both air and gas and to provide for this, a diaphragm regulator was found necessary in order to avoid serious interference with the mixture proportions due to excess of pressure on one side or the other. The regulator is so constructed that the pressure of the gas is utilized to manipulate a damper valve in an air supply connection, by means of which increase of pressure in the gas opens up the passage in the air connection and vice versa.

The efficiency of surface combustion appliances compared with Bunsen type burners varies with conditions and for

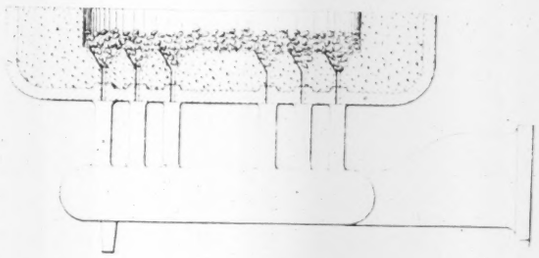


Fig. 14 Modification of Improved Type of Burner that Allows Quick Initial Heating

this reason the author gives figures based on a limited scope of experiments confined to domestic appliances operating on city gas, all of which were formed by removing the Bunsen burners from standard commercial appliances and substituting the surface combustion burners. Top burners were tested by observing the consumption and time to raise a weighed body of water from an initial low temperature up to 200 deg. fahr. with fire beds of various materials and thicknesses, different sizes, shapes and materials of vessels, differing distances between flame and vessel, on all sorts of gas and mixture pressures, etc. It was universally found that with conditions as nearly identical as possible, the surface combustion burners will accomplish an equal amount of heating with less gas than the Bunsen burners, although the relative economy seems to be dependent upon the construction of the burner, the stove and the water vessel.

In one series of tests, a surface combustion burner, with 4⅜ in. hearth with 5/16 to ⅜ in. refractory material, ½ in. deep, and covered at the edges by a cast-iron ring with vents between it and the vessel, was tested in comparison with a Bunsen burner of standard construction consuming 15 cu. ft. of gas per hour. In both cases these burners were turned down to a simmer, and it was found that the consumption of gas necessary to keep the water just below boiling point was 5.2 cu. ft. per hour for the Bunsen burner and 2.42 cu. ft. per hour for the surface combustion burner, a ratio of 2.15. In another series, with a standard Bunsen burner and a surface combustion burner with a thick silica bed surface, the ratio of consumption of the gas varied between 1.71 and 1.75. In the latter, when by a slight change the burner was converted into a quick heating design, the ratio was raised to 1.80. In numerous other tests, this ratio decreased according to conditions, and in one case went as low as 1.2, but in all cases of these low ratio results, it was found that the surface combustion burners were either of inefficient design for the purpose or improperly applied; under favorable conditions involving the application of an efficient type of burner and the most advantageous conditions of transfer of heat to the vessel it was found that the surface combustion appliances operated with a consumption of gas about one-half that of the standard Bunsen burner when under continuous operation. For intermittent work the saving is not nearly so favorable.

With this system, however, the cost of operating the fan for producing the air pressure must be taken into account. Assuming the case of a domestic range with a burner operating 3 hr. per day and 300 days per year, at an average rate of 50 cu. ft. per hour, the surface combustion burner operating at an average saving of 40 per cent over a corresponding Bunsen burner, would effect a saving in cost of gas of approximately $30 per year. The cost of operating the fan under the most unfavorable and inefficient conditions would not greatly exceed $8 for 900 hr. of operating for the year. This makes the net saving in operation about $22 per year.

AMERICAN SOCIETY OF CIVIL ENGINEERS

Vol. 39, no. 9, November 1913, New York

Painting Structural Steel: The Present Situation, A. H. Sabin (Abstracted)

Stresses in Wedge-Shaped Reinforced Concrete Beams, W. Cain

Painting Structural Steel, A. H. Sabin (6 pp., to be presented at the meeting of the Society January 7, 1914. *p*). After several attempts to classify paints, a committee of five chemists from different parts of the United States, with the approval of the American Society for Testing Materials, made a series of tests of the principal pigments, and of some other substances, on steel immersed in water, and arrived at concordant results. In the report of this committee the pigments were classified, *according to their water value*, into three groups, namely, inhibitors, indeterminates, and stimulators. While it was expressly stated in the report that this was a classification as regards water only, the names (partly through ignorance, partly owing to their apparent convenience for advertising purposes) came to be widely used to classify pigments in oil, which is misleading, since any classification of pigments in oil should be based on their behavior in oil, usually radically different from that in water.

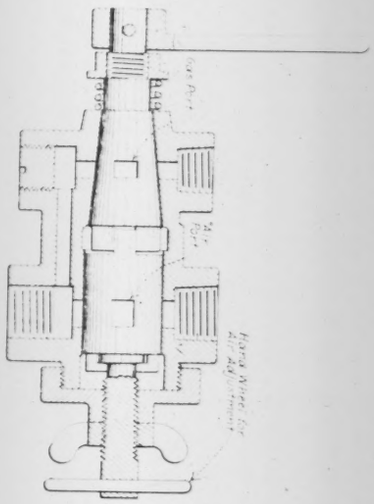


Fig. 15 Details of Double-Ported Mixing Valve with Adjustment for Ratio of Air to Gas

The important practical question is whether paints have been or can be improved as to being non-porous and dur-

able. This is essentially dependent on the relation between the pigment and the oil. As to the true nature of this relation, very little is known; but something is known about its visible manifestations. Thus, 1 lb. of dry red lead mixed with ¼ lb. of oil makes a paint of ordinary consistency, but a pound of dry lamp-black requires many times as much oil; white zinc takes twice as much oil to make a paint as white lead, the latter in its turn taking nearly twice as much as red lead. While these facts are known, there is no information as to why it is so. As to red lead paint, it is now known that its value depends on the quantity of red lead proper it contains, as compared with that of litharge. Coarse red lead always contains litharge, because the litharge in the middle of a large particle is never oxidized. Manufacturers are therefore grinding their litharge to an impalpable powder before roasting it, with the result that now paint with 94 per cent of true red lead is on the market. Unlike the old paint which worked with difficulty and unevenly in application, the new article is inactive in oil, and brushes out smoothly like a house paint. This enables the painter to cover 50 per cent more surface with the same quantity, and still get a coating of uniform thickness which gives more protection than the thin portions of the paint formerly used. In addition to economy in the cost of paint and labor, there is the further advantage that less skill is required and therefore a lower salaried man may be employed. Red lead paint is now offered as a paste ready to be thinned with more oil; such a paste keeps for a year or more, and gives a better mixture than hand-mixing, as well as eliminates the presence of a dusty pigment. Such red lead dries more slowly than the older kinds, but this can be obviated by the use of a little japan drier; only 1 pint of drier is needed to make 1 gallon of mixed 94 per cent red lead, anything above that proportion being excessive and objectionable.

Important work is also going on with respect to standardization in the use of linseed oil, specifications having been adopted by the American Society for Testing Materials for North American raw linseed oil, which is of better quality than that made from South American seed. From tests made by the American Society for Testing Materials on the Havre de Grace bridge, the author concludes that the durability of any good paint may be increased one-half, and probably doubled, by proper care in its use as compared with average practice.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Vol. 25, no. 3, August 1913, Washington, D. C.

U. S. S. "Cassin" and "Cummings": Description and Trial Performances, Henderson B. Gregory
The Saving of Heat Units in Marine Machinery, Henry C. Dinger (Abstracted)
Chemical Indicators in Volumetric Work: Preparation of Normal Solutions, and Determination of Chlorine in Boiler Water, H. T. Dyer
The United States Naval Engineering Experiment Station, Annapolis, Md., E. J. King
Description of Nürnberg Two-Cycle 450-B.H.P. Heavy Oil Engines, Louis Shane
An Analysis of Crankshaft Stresses: Determination of Stresses in Two- and Three-Bearing Four-Cylinder Crankshafts, K. W. Najder

THE SAVING OF HEAT UNITS IN MARINE MACHINERY (p. 379, 22 pp., 2 figs. *cd*). From data based on trials of the *Delaware, Michigan, Utah* and *Florida*, the author advocates the combination of reciprocating engines for the high pressure end and turbines for the low pressure end, with reheaters and series feed heaters as an additional means of saving heat. By the combination of reheaters and series feed heaters a reduction in the average fuel consumption of from 5 to 10 per cent can be made, at a cost and added weight that, considering total weight and cost of plant, is almost negligible. In the future, the author expects to see electric motor drives on the shafts with the current supplied partly by Diesel engines and partly by steam turbines, with several generating units of each type. The exhaust from the oil engine could be utilized to assist in the generation of steam in the boilers, and the feed water for boilers might be used as the cooling water for the oil engine. Such a combination, in addition to its high economy, would enable the propellers to be operated by either the oil engine or the steam turbine. This requires, however, an entirely reliable engine that can be operated satisfactorily on ordinary fuel oil, either asphalt or paraffine base. The heat requirements of the auxiliaries are fully discussed.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Vol. 29, no. 7, October 1913, Pittsburgh

The Use of Pulverized Coal in Metallurgical Furnaces, James Lord (Abstracted)
Composition Flooring, H. M. Hooker (Discussion)

THE USE OF PULVERIZED COAL IN METALLURGICAL FURNACES, James Lord (53 pp., 7 figs. *deA*. A short bibliography of the subject attached). Pulverized coal has been used now for more than ten years. From the first it was apparent that its economical use depended upon the absolute control of the feed by the burners. Success in the use of this fuel requires (*a*) that both the free and combined moisture be expelled by artificial heat, down to 0.5 per cent; (*b*) that at least 95 per cent of the pulverized matter should pass through a 100-mesh sieve, and over 80 per cent through a 200-mesh sieve. The delivery to the furnace must secure proper feed, and when used in metallurgical furnaces, the coal should have a high volatile content. The equipment of the Lebanon plant of the American Iron and Steel Manufacturing Company is such that the slack coal is conveyed automatically from the coal to the pile, then taken by screw conveyors to the dryers, and in the same manner from the dryers to the pulverizers. It is not touched by hand or shovel from the freight car to the furnace. At the end of each line, there should be an overflow pipe to prevent the coal from choking up the screw, if anything should happen to the crosslines. Otherwise should the coal overflow near an open fire, it will burn back very quickly. To each of the furnaces is attached a hopper carrying about 15 hours' supply of pulverized coal. On several occasions the fuel has ignited in these hoppers, but it was only necessary to stop the supply and to feed the burning coal into the furnace until the tank was emptied. There is no danger of explosion under these conditions, and during the entire experience of the author with this fuel he has had no explosions. Proper attention to the pulverizing plants and machinery will eliminate the only possible danger from coal in suspension in a room coming into contact with flame. It is, however, dangerous to have the dryer in the coal pulverizing house, for the reason that if an accident should occur, causing the coal to overflow, it might be drawn into the fire chamber of the dryer with possible injury to employes. Further, the department in which the coal grinding is done is usually dangerous, for it is almost impossible to grind

coal without having dust escape, but a change of air should minimize the possibility of explosions, which can also be achieved by the use of exhaust fans.

As regards the grade of coal that can be used, coal piles are not suitable, as they are mostly anthracite and dirt. The great difficulty of low-grade coal is the deposition of slag, which requires frequent opening of the furnace front to attempt removal, which is not always so easy. The best coal obtainable should be used, at least until all the details of operation have been fully perfected.

As to the need for drying coal, the author states that dry coal is very desirable, but it is a matter of first cost; and with limited capital for first installation, wet coal may be used successfully. Where it is used, an igniting flame is to be provided.

Design of Furnaces using Pulverizing Coal. The first essential of a pulverized coal furnace is a large combustion space, where the flame can occupy about four times the volume of the flame produced by an ordinary grate fire. This entire combustion space must be free from any metallic cooling surface, which stifles the flame and stops combustion. Any mechanism which will give a uniform mixture of coal and air with both under control can be used for feeding pulverized coal. Powdered coal flushing must be guarded against, since this kind of coal will run almost like water. The screw feeding the coal, however, is usually made very long, so as to introduce enough friction to keep back the flush of coal. The air used in the pulverized coal burner has been greatly reduced from 20 lb. on cement furnaces of the early days to about ½ oz. on metallurgical furnaces. Powdered coal is very destructive to the life of the furnace, owing to the tendency of concentrating the heat in an action similar to that of a blow-pipe, the wearing effect being due to the impingement of the coal, and the tendency of the ash and brick to flux together. The later designs of furnaces prevent this somewhat by the use of low-pressure air introducing the coal at a very slow velocity, and spreading the flame over as large an area as possible.

TABLE 7 COST OF PULVERIZING COAL

Capacity of Grinding Room, Tons per Hour	Finished Product through 100-Mesh Screen, Per Cent	Horsepower at ¾c. per Kw-Hr.			Labor		Cost per Ton for Maintenance, Cents	Total Cost per Ton, Cents
		Total	Hours per Ton	Cost per Ton, Cents	Men at $2, per Day	Cost per Ton, Cents		
2	95	45	22.5	11.25	1	10.00	3.33	24.58
3	95	60	20.0	10.00	1	6.65	2.22	20.88
4	95	75	19.0	9.50	1	5.00	1.70	16.20
5	95	85	17.0	8.50	1	4.00	1.20	13.70
10	95	170	17.0	8.50	1	2.00	1.20	11.70
25	95	425	17.0	8.50	2	1.70	1.20	11.40

As to economy, the economy over oil is fully established. As compared to producer gas, it is expected that equal economies will maintain. Where checker work and ash troubles are objectionable, producer gas will be preferred, but where the ash can be taken care of, there seems to be a saving by the use of pulverized coal amounting to about 25 per cent.

In the discussion which followed, H. R. Barnhurst of the Fuller Engineering Company described the two methods by which pulverized coal may be burned. The first may be called "the long flame method." It is a progressive burning of the coal used where the character of the work and form of furnace demand that the flame shall be elongated so that the heat may be developed in close proximity to the work done, and not conveyed by gases from the initial point of firing. The high velocity air jet is used with this method of burning.

The second method involves a shorter flame and lower velocity, both of air and coal. It has less cutting action upon the charge or brickwork, and the fuel burns close to the nozzle developing through the whole fuel cloud almost instantly. The second method has been the latest developed, and appears to be the most promising.

The long flame method is employed in the cement kilns, but is not adapted to the various heating furnaces, nor to use under boilers. The speaker gave a very interesting table of calculated temperatures attained in burning carbon which showed that with slight excesses of air, temperatures in close proximity to 4000 deg. fahr. may be attained. He also gave step by step the mechanical processes of pulverization.

How far savings may be obtained by the use of pulverized coal was shown by E. W. Shinn, who stated that the American Iron and Steel Manufacturing Company was installing a plant in connection with open-hearth furnaces which were now using oil as a fuel, and where a $32,000 investment would save $100,000 per year.

A. W. Raymond gave some interesting data on the cost of pulverizing the coal gained from experiments and tests of several large users, for which see Table 7. This table shows that the larger the quantity of coal handled in the milling plant, the smaller the cost per ton for pulverizing, which applies to all other operations as well. The total cost for preparing the coal in a plant having a capacity of 5 tons per hour or more will not amount to over 35 cents per ton (the speaker gave in detail how he arrived at this figure) and in a great many cases in the cement industry in the United States this has been brought as low as 28 cents.

Use of pulverized coal under boilers. E. W. Shinn stated that it was applied to boilers by the American Iron and Steel Manufacturing Company, but the boiler settings were not altered to suit that changed requirement, and consequently the conditions were not of the best. They succeeded in evaporating about 8½ lb. of water per lb. of coal used.

A. Stucki stated that a local plant obtained an actual evaporation of 10½ lb. of water per pound of pulverized coal. He made an investigation of a plant in the Pittsburgh district which started to use pulverized coal, and found the fuel economy good; there was absolutely no smoke, but nevertheless the system was soon abandoned. The reasons for doing so were as follows: The heat which was obtained by blowing the coal dust from opposite sides, and letting the two flames meet in the center of the firebox, was very intense and very hard on the firebox lining and the firebox in general. The first cost of the dryer, the mill, the blowers, the conveyors and the feeding apparatus was considerable. Large additional floor space was needed, while the upkeep of all this additional machinery was considered unfavorable; the power necessary to drive the additional machinery was about 5 per cent of the power produced. Finally, the danger of leaks in the conveyors and consequent danger of explosions was also considered objectionable.

INSTITUTION OF ELECTRICAL ENGINEERS

Vol. 51, no. 220, June 1913, London

Power Supply on the Rand, A. E. Hadley (Abstracted)
Independent Steam Condensing Plants, W. A. Dexter
Air-Cooled Jacketing in Hollow Walls by Electric Fans, J. W. Mears

Power Supply on the Rand (p. 2, 56 pp. *d*). Description of the power generating system of the Victoria Falls and Transvaal Power Company, Ltd., operating both hydro-electric and steam power, and selling compressed air in addition to electric power. The Prat ejector system of induced draft is used throughout, adjacent boiler units being connected to a common ejector chimney, the top of which, in the Rocherville station, is only 90 ft. above the boiler house floor; an electrically-driven rotary fan blows cold air through the ejector chimney, thereby producing the necessary suction in the flues, with a torpedo-shaped damper in the air-pipe regulating the pressure of the air jet. Although a small coal mixed with duff produced by the coal cutters is used, the plant is absolutely smokeless. Babcock & Wilcox marine type boilers with chain grate stokers are used, each having an integral superheater and economizer.

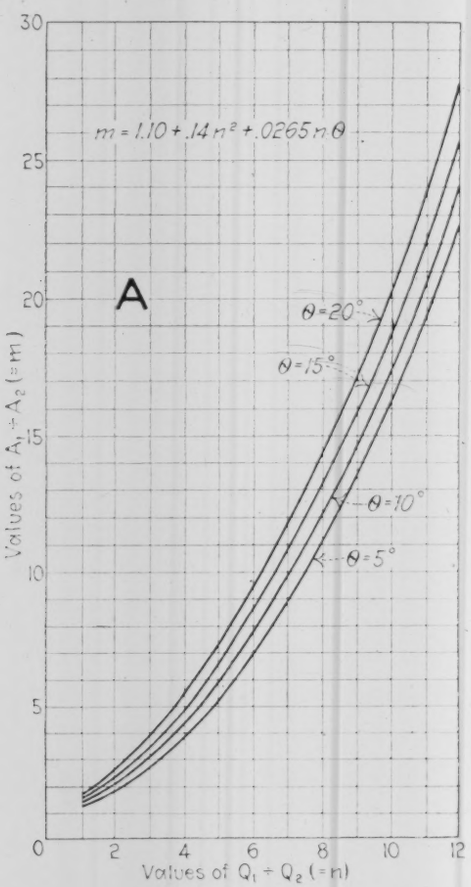


Fig. 16A Values of *m* Giving Minimum Loss

As the consumers participate in the profits, they have at definite periods a right of access to the books in order to determine the cost of a unit of power. The form in which the returns from each station are made, is based upon the underlying idea of energy expressed in kilowatt-hours. The energy value of each pound of coal, usually expressed in B.t.u., is converted to kilowatt-hours by multiplying by 0.000293; thus a coal of 11,300 B.t.u. per lb. has a value of 3.3 kw-hr. per lb. In a similar manner the energy in the steam is calculated from Mollier's steam tables, the boiler efficiency being the ratio of the kw-hrs. in the steam (less the energy supplied from the hot well) to the kw-hr. in the coal. Other efficiencies are calculated in a similar manner.

The compressed air system, probably the largest of the kind in the world, is described in detail, as well as the air meters and measurements adopted. Compressed air is supplied to the various mines at an average pressure of 100 lb. per sq. in. delivered on the consumer's property; the maximum load is nearly 60,000 kw.; the distance between two extreme mines served by the air-pipe system is approximately 14 miles, with the diameter of the pipe varying from 24 in. to 9 in. The air is supplied by two groups of compressors, one steam-driven, and the other electrically driven. At first it was feared that, with such large compressors running in parallel on a common pipe system, the machines unless automatically controlled, would tend to hunt with a variation in load; actually, however, only one or two cases have been recorded of a compressor dropping out to atmosphere, and even this was due to abnormal disturbances in the electric supply system, while the steam driven compressors have operated satisfactorily from the start. As to losses, tests have shown that of the units of air sent out, 95 per cent have been recorded at the consumers' meters, 3 per cent have been lost in transmission, and 2 per cent unaccounted for. The drop in pressure to the various mines varies with the distance and size of pipe, but the average pressure drop is not more than 6 lb. With a monthly air load factor of 50 per cent, the plant appears to be a success financially.

INSTITUTION OF MECHANICAL ENGINEERS

No. 2, 1913, London

Some Effects of Superheating and Feed-Water Heating on Locomotive Working, F. H. Trevithick and P. J. Cowan.
The Design of Volute Chambers and of Guide-Passages for Centrifugal Pumps, Professor A. H. Gibson (Abstracted)
An Improved Governor for Water Turbines, Percy H. Pitman
An Electrical Measuring Machine, P. E. Shaw

The Design of Volute Chambers and of Guide-Passages for Centrifugal Pumps, A. H. Gibson (p. 519, 45 pp. *etA*). The paper is based mainly on data obtained from recent experiments at University College, Dundee. The author in another publication has established the following formula for the loss at impact of impinging streams, only one of which is deviated by the impact

$$\text{loss} = \left\{ a\left(\frac{n}{m}\right)^2 + b \right\} \frac{v_2^2}{2g} \text{ ft-lb. per lb.} \ldots [1]$$

where v_1 is the velocity of the primary (undeviated) stream; A_1 area of the same stream; v_2 velocity of the impinging (deviated) stream, and A_2 its area; θ angle of impact; $m = A_1 : A_2$, and $n = Q_1 : Q_2$, the latter being the volumes, in cu. ft. per sec., conveyed by the two streams. The author found experimentally also that the old formula

$$\text{loss} = \frac{(v_2 \sin\theta)^2 + (v_2 \cos\theta - v_1)^2}{2g} \text{ ft-lb. per lb.} \ldots [2]$$

is quite inaccurate. What follows is based on the assumption that the state of affairs during the impact of each of the streams leaving the impeller of a pump is analogous to that in a single stream impinging under the same conditions

as to direction and velocity. If v_d be the velocity of flow along the discharge pipe of a pump, and the loss of energy proportional to $(v_1 - v_d)^2$ be also taken into consideration (experiments on flow in diverging passages have previously established that if the sides in a circular pipe diverge at an angle of 6 deg., the loss of head including friction is about $0.13(v_1 - v_d)^2 : 2g$, and is greater for angles greater or less than 6 deg., amounting to $0.15(v_1 - v_d)^2 : 2g$ for usual angles of divergence in the volute chambers of pumps); let further $v_1 : v_d = 3.85$, which is in close agreement with practice, then the total increase in pressure energy after leaving the impeller is given by:

$$\frac{v_2^2}{2g}\left[(1-b)-\left(\frac{n}{m}\right)^2\left\{0.15+a\right\}\right] \text{ ft-lb. per lb} \ldots\ldots [3]$$

where m is the ratio of the cross-sectional area of the volute at the point under consideration, to the area of the stream leaving the impeller, and the values of a and b are given by the formulae:

$$a = \frac{0.0052}{m}\theta^{0.5} (\theta \text{ in deg.}); \; b = \left(\frac{m-1}{m}\right)^2 + \frac{0.00046}{m}\theta^{1.5} \ldots [4]$$

If the ratio $Q_1 : Q_2$ $(= n)$ be known, the known values of a and b enable the value of m for maximum gain of pressure to be calculated by successive approximations. To facilitate the solution of practical problems the range of values of θ from 0 to 20 deg. and of m from 1 to 28 have been examined in this way, and it appears that the value of m for maximum gain of pressure is given with a close degree of accuracy by the relationship:

$$m = 1.10 + 0.14n^2 + 0.0265n\theta \ldots\ldots\ldots\ldots [5]$$

where θ is expressed in degrees. The best values of m for different values of n and θ are shown graphically in Fig. 16 A, while B shows what fraction of the kinetic energy of discharge is converted into pressure energy with these best values of m.

In the volute chamber, Fig. 16 C, let θ be the angle of impact of each of the discharging streams; N number of vanes or passages in the impeller; γ their discharging angle; r the radius, and b the breadth of the impeller at its outer periphery. The effective area of each of the impinging streams, normal to its direction of flow, is $\frac{2\pi rb}{N}\sin\theta$ (neglecting the space occupied by the vanes), and the area of the volute at this point for minimum loss is

$y =$ (effective discharge area of each passage) $\times m$

m being that of formula [5], or of the curves of Fig. A. From an examination of curves Fig. B, and a table showing the proportion of kinetic energy of discharge which may be converted into pressure energy with a volute of best form, the author deduces that in a pump of this type, the smaller the number of vanes, the more efficient the corresponding volute, and other things being equal, the pump also, with the qualification that too few vanes give insufficient guidance to the water, and increase the tendency to the formation of circulatory currents behind the discharging edge of each vane. The author supports this view by referring to the Wisconsin experiments (Bulletin, University of Wisconsin, 1907, No. 173).

The experiments at University College, Dundee, were made with a pump having a single encased impeller of diameter 13.5 in.; breadth 0.5 in.; $\gamma = 30$ deg.; having ten vanes and designed to discharge 425 gal. per min., at 1250 r.p.m., against 85 ft. head, and circular section of volute as shown in Fig. D. The cross-section was varied, first, by filling in the spaces S_1S_1 by plaster of paris (experiments *a*), and then by filling up the space S_2 with a wooden strip bent to shape (experiments *b* and *c*). The areas of the volute at sections *A*, *B*, *C*, *D* (Fig. C), 90,180,270,360 deg. from the cutwater respectively, are given in Table 8. Volute *a* forms a fair approximation to the calculated best form; the original volute is of good proportions towards the outlet *D*; *b* is of good form about *B*, but restricted in area

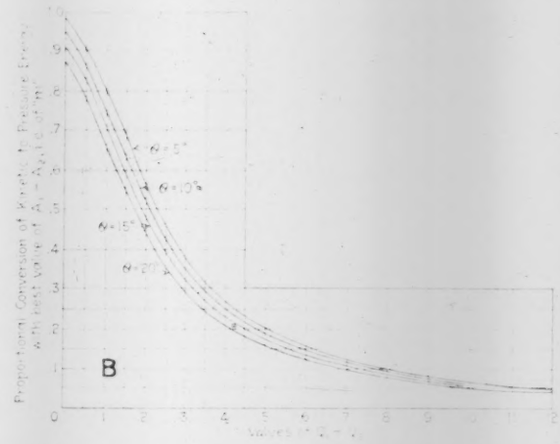


Fig. 16B Proportional Conversion of Kinetic to Pressure Energy

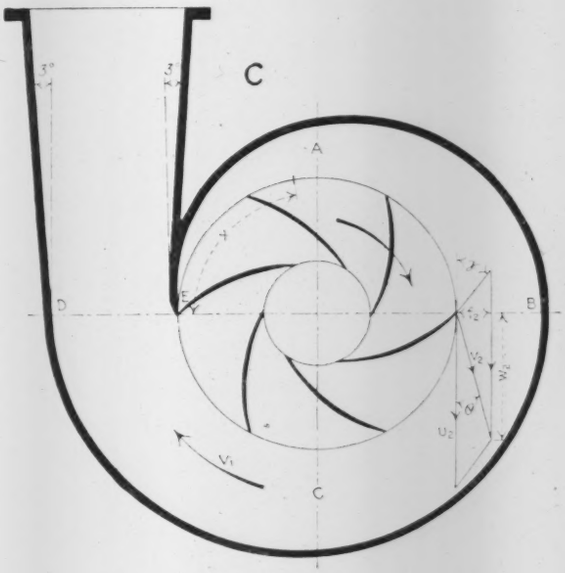


Fig. 16C Volute Chamber

over the latter half of its length; *c* is still more restricted, while *d* is considerably smaller throughout than the analysis calls for. The results of efficiency tests with these volutes are shown in Fig. E: *a* increases the maximum overall efficiency of the pump, as compared with the original volute, by approximately 6 per cent, the efficiency being generally inversely proportional to the difference between the actual form of the volute and that indicated by theory.

The author further compares modern types of volutes and those designed by his analysis, and shows that the most efficient pumps are those showing the closest coincidence between the values calculated and the actual proportions of

volute. In general, he found that the volutes were too large for maximum efficiency. It appears further that, as far as the conversion of energy was concerned, a simple pump of the type described was inherently less efficient than a turbine pump in which the effective number of vanes was equal to that number discharging into each of the guide-passages. This disadvantage might be reduced by a series of guide-

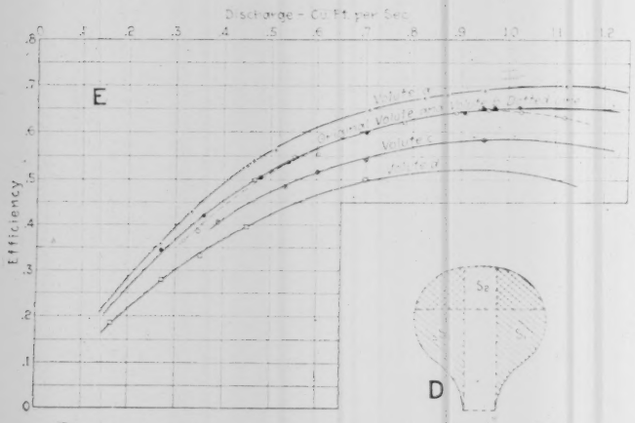


Fig. 16D Volute Used for the Dundee Experiments
Fig. 16E Results of Efficiency Tests with Different Volutes, Dundee Experiments

vanes in the volute (Fig. F), which could be of sheet metal bent to shape and cast in position; they would not cost much, and would increase the possible conversion of energy roughly by 100 per cent.

As to the best form of section for the volute, the author recommends an arrangement of a chamber with parallel

Fig. 16F Volute with a Series of Guides
Fig. 16G Section for Volute, Straight Sides inclined outwards at 22.5 Deg.

sides of the same width as the impeller. It could also be easily machined, and the addition of guide vanes would be comparatively simple. With small pumps, however, it would have a comparatively small hydraulic depth, and its friction losses would on this account tend to be high. Experiments on diverging passages indicate, however, that fairly good results could also be obtained in the average pump with straight sides inclined outwards at about 22.5 deg. (total included angle 45 deg., cp. Fig. G); with this form of section the outflowing streams diverge at about the best angle when moving with their highest velocity, while the interior surfaces can be smoothly finished off with little difficulty. With either form of section, with the best areas the velocity in the volute is usually from three to four times that permissible for flow through the discharge pipes, and, to utilize as much of this kinetic energy as possible, the connection between the volute chamber and discharge pipe should be made by a tape pipe having walls diverging at about 6 deg., as in Fig. C. The design of guide passages for turbine pumps is also discussed in detail.

In the discussion which followed, A. Marshall Attack objected to the treatment of the theory of pumps from the point of view of a high velocity stream impinging on a lower velocity stream, a very undesirable condition in a centrifugal pump. With impellers having from six to twelve vanes, the writer has not found from practice that the larger number of vanes had a seriously deteriorating effect upon the efficiency of the volute, over 50 per cent of $\frac{v_2^2}{2g}$ being converted in comparatively small pumps. Professor Gibson wrote in reply that the first statement was true, but that every pump fitted with a volute chamber was subject

TABLE 8 AREAS OF VARIOUS SECTIONS OF THE VOLUTE USED IN THE DUNDEE EXPERIMENTS

	Area of Volute, Sq. In., at Point:			
	A	*B*	*C*	*D*
Calculated Best Form	0.79	1.77	3.30	5.36
Original Volute	1.1	2.6	4.1	5.6
Modification *a*	0.87	1.9	3.5	5.5
b	1.1	2.2	3.0	4.3
c	1.1	2.2	2.5	3.0
d	0.77	1.3	1.6	1.9

to this condition, and what was desired was to suggest means of reducing the shock loss which it inevitably involved. The second statement, that over 50 per cent of $\frac{v_2^2}{2g}$ is converted, the writer doubts.

Robert H. Smith recalled the experiments of Professor Inokuty, of the Imperial Japanese University, Tokyo, (for a full text in English see The Technical Papers of Ariya Inokuty, Tokyo, 1913, p. 181 to 280, *Editor*), who, in his investigation assumed that the hydraulic loss in a flow of uniform section and velocity equaled $f\frac{l}{r}\frac{v^2}{2g}$, with l the length and r the mean hydraulic radius of the channel. As a matter of fact, the loss varies neither as v^2 nor as l/r. The latter assumption was made also by Professor Gibson. In reply to that part of the criticism, Professor Gibson states that his experiments on taper pipes have shown that over the whole range of velocities investigated the loss was, within the limits of experimental error, proportional to $(v_1 - v_2)^2$. The most important aim, according to Professor Smith, was to find the value of v_1, which yielded maximum P when other things such as m, θ, v_2 and v_d were fixed by other requirements. By ordinary differentiation, this value was found to be

$$v_1 = \frac{0.15}{0.15 + a} v_d$$

and this value of v_1 yielded the maximum pressure energy

$$2gP_{max} = (1 - b)v_2^2 - \left(0.15 - \frac{0.0225}{0.15 + a}\right)v_d^2$$

This value of P_{max} increases with v_2 directly, and with v_d inversely. This equation makes v_1 less than v_d, and therefore involves a volute chamber of large size. A long and interesting discussion of the paper by Mr. Price is omitted here as it is unsuitable for abstracting.

INTERNATIONAL RAILWAY FUEL ASSOCIATION

Proceedings of the Fifth Annual Convention, May 1913, Roanoke, Va.

Sub-Bituminous and Lignitic Coal as Locomotive Fuel
Firing Practice
Scaling of Locomotive Boilers and Resultant Fuel Losses
Self-Propelled Railway Passenger Cars

SUB-BITUMINOUS AND LIGNITIC COAL AS LOCOMOTIVE FUEL (p. 43, 15 pp. *gp*). The paper describes and illustrates, among other things, several devices for preventing spark troubles that are particularly apt to occur when sub-bituminous and lignitic coals are burned owing to the high drafts necessary to burn them. The following cost data are quoted (results of a dynamometer car test were used as the basis of computation):

Bituminous Coal		Sub-Bituminous Coal	
Price at Buxton, Ia.	$133.83	Price at Hudson, Wyo.	$153.26
Cost to haul to Cody, Neb.	196.26	Cost to haul to Cody, Neb.	171.46
Cost to return empties	54.63	Cost to return empties	47.88
Total cost	$384.72	Total cost	$372.60
Saving in favor of Wyoming coal			$12.12

SCALING OF LOCOMOTIVE BOILERS AND RESULTANT FIRE LOSSES (p. 270, 14 pp. *gd*). General discussion of the causes of scaling of locomotive boilers. Contains complete advance data of the experiments on the transmission of heat into steam boilers about to be commenced at the United States Bureau of Mines, in Pittsburg, under the direction of Mr. Henry Kreisinger. The Committee is of the opinion that pure amorphous graphite will be of material assistance to any boiler. By adhering to the plates and tubes, it prevents anything further sticking thereto; it has also a tendency of penetrating into cracks in the scale, and rendering it softer.

NEW YORK ELECTRICAL SOCIETY

New Series, June-October 1913, no. 6, New York

The Flying Boat, Lieut. T. G. Ellyson, U.S.N. (Abstracted)
The Application of the Gyroscope to the Flying Machine, Elmer A. Sperry (Abstracted)
Description of the Elevator Equipment and the Electric Installation in the Woolworth Building, New York City, Charles E. Knox

SAFE FLYING AND THE FLYING BOAT, Lieut. T. G. Ellyson (18 pp., 11 figs. *dh*). The author gives an historical account of the development of the flying boat, and a fairly complete description of the Curtiss boat. At first the propeller was chain driven, the assumption having been that propellers of large diameter and pitch could be used, and hence less power required, with a corresponding reduction in weight, owing to the reduced consumption of gasolene and oil. The chain, however, used to break so often, that the direct-drive propeller had to be adopted. Another interesting feature of the flying boat is the arrangement of the main gasolene tank; to keep the weight as low as possible and to reduce the head resistance, the main gasolene tank (42 gal.) is situated in the hull of the boat, with an auxiliary feeder tank of 8 gal. capacity attached to the side of the engine bed, in order to get a head of gasolene for the carbureter. Gasolene is pumped from the main to the feeder tank by means of a plunger pump driven from the water pump shaft, there being an overflow to the main tank to take care of excess. In case this pump breaks down, a small electric light is automatically lighted as soon as the supply in the feeder tank drops to 4 gal. Then the operator has only to close the vent on the main tank, and put pressure on this tank by means of a hand air pump, so as to force gasolene to the feeder tank. On the whole, the author, who made a number of flights in the Curtiss flying boat, states that the boat is quite easy to handle both in the air and on the water.

SAFE FLIGHT AND AUTOMATIC STABILIZATION OF AEROPLANES, Elmer A. Sperry (13 pp., 16 figs. *d*). The author describes a gyroscopic system of control, and holds that, in addition to all the longitudinal control, in turning curves it produces automatic banking to the point of zero "skid," either inwardly or outwardly. The author describes various apparatus where gyroscopes are used and calls attention to the fact that a single gyro is responsive to all prime components of universal compound motion, and that for purposes of stabilization, only compound gyro equipments must be used, where each gyro is responsive only to motions about a given axis, and entirely unresponsive to motions about every other axis. The Sperry aeroplane stabilizing equipment comprises two separate combinations of devices, one for maintaining longitudinal stability and another for maintaining lateral stability.

The longitudinal stabilizer uses three directive factors for controlling the movements of a pilot valve which in turn controls a compressed air cylinder operating a piston attached to the horizontal rudders. The controlling factors are: (*a*) the gyro which through the pilot valve operates the horizontal rudders against tendency to tip about the horizontal axis; (*b*) an anemometer which operates the pilot valve to volplane the machine in case the speed drops below the critical speed necessary for sustaining the plane; (*c*) a hand-setting device which permits the aviator to set the stabilizer for any inclination of climb or descent. The air platen further acts to adjust the throw of the levers, so that when running at slow speed a small tipping is counteracted by a suitable throw of the rudders. This is made necessary by the fact that the plane is more sensitive to inclinations of the rudders when running at high speed.

The lateral stabilizer serves as a directive factor acting on the pilot valve to control the movements of the ailerons so that they should operate to counteract against tipping laterally. When turning, the lateral stabilizer operates the control mechanism to bank the machine to an angle sufficient to prevent skidding. The gyros are driven by a three-phase alternating-current motor. The weight and dimensions of the various parts of the apparatus are as follows: the weight of the generator is about 25 lb., and it occupies a space about 6 in. by 6 in. by 10 in. The lateral stabilizer weighs about 18 lb. and is small enough to be conveniently disposed at the back of the aviator's seat. The longitudinal stabilizer weighs about 17 lb., and is placed below the aviator's seat in such a position that he can see its operation at all times. The author states that his apparatus has been thoroughly tested at San Diego, under the eye of Mr. Curtiss and the officers of the Aviation Corps of the United States Army. No precise data of tests are given in the article reported.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Vol. 21, no. 7, September 1913, Newcastle-upon-Tyne

SUMMER MEETING IN HOLLAND (p. 343, 15 pp. *d*). During this meeting several plants were visited, and their products inspected. It is reported that the present Kromhout heavy oil engines are of the two-cycle hot-bulb type. The fuel is fed from a float chamber to two pumps each of which has two delivery valves, and the speed of the engine is regulated by altering the length of the stroke of the pump. The governor is of the hit-and-miss type, but a knife-edge lifts the working striker out of engagement on the idle stroke thus reducing wear and tear. On the larger sizes of engines, starting is effected by pressure from a bottle filled with exhaust gas. The exhaust-receiver is water cooled.

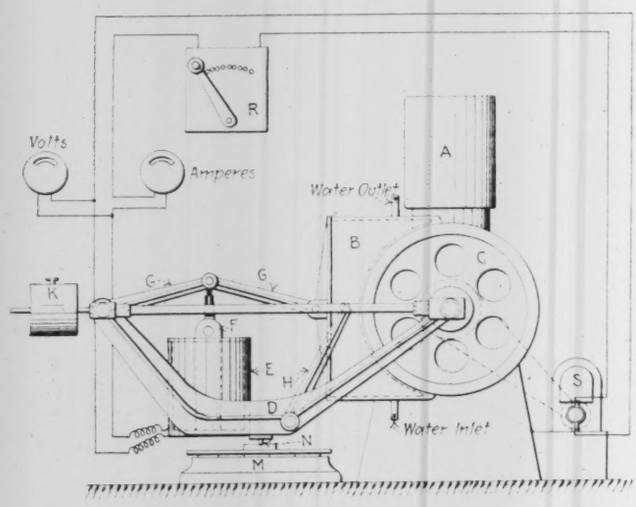


FIG. 17 JOHNSON ELECTRICALLY CONTROLLED DYNAMOMETER FOR TESTING GAS ENGINES

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS

Vol. 63, no. 6, July 1913, Newcastle-upon-Tyne.

Miners' Electric Safety Lamps
The Ochwadt Self-Registering Water Gage (Abstracted)
Messrs. F. Robson's & Company's Improve Air-Gage
The Davis-Biram Anemometer (Abstracted)

THE OCHWADT SELF-REGISTERING WATER GAGE (p. 240, 2pp., 2 figs. *d*). This is a gage designed to record continuously the pressure of ventilating current in coal mines, or the pressure or vacuum of air or gas in gas-plants and ironworks. The apparatus is formed with a base of two cylinders of equal width which merge into one large cylinder at the extreme base, and are filled with water up to a certain point. In each cylinder is a float, the two being joined together by a chain passing under a wheel in the single cylinder at the base, and fixed to one of the floats is a vertical rod to which the recording pen is attached. The recording chart is at the top of the apparatus, on a drum rotated about its vertical axis by a clock which may be so adjusted as to rotate the drum either once in 24 hours or once in seven days. The air is admitted through an inlet pipe into the cylinder opposite from that containing the float to which the writing device is attached.

THE DAVIS-BIRAM ANEMOMETER. For its description see *Coal Age*, November 1, 1913, p. 655.

SOCIETY OF AUTOMOBILE ENGINEERS

Vol. 5, no. 2, November 1913, New York

The Development of an Electric Tractor for Handling Freight Cars Over Tracks Laid on City Streets, T. V. Buckwalter
An Electrically Controlled Dynamometer for Testing Gas Engines, Nathan C. Johnson (Abstracted)
The Internal-Gear-Driven Truck Axle, Viggo V. Torbensen
A Correlation of the Magnetic and Physical Properties of Steel, Charles W. Burrows

AN ELECTRICALLY CONTROLLED DYNAMOMETER FOR TESTING GAS ENGINES, Nathan C. Johnson, introduction by R. D. Carpenter (4 pp., 3 figs. *d*). The electrically controlled dynamometer, consisting of a dynamometer with a field mounted on a cradle so that it can oscillate freely, is, in the opinion of Professor Carpenter, probably the most desirable of any dynamometer yet produced for the accurate measurement of developed power, but is expensive in use where a large number of units are to be tested. The device illustrated and described in the present article is an application of an electrical load-controlling device to a peculiar form of Prony brake, and is stated to have proved very satisfactory in practice.

The principle of operation of the device shown in Fig. 17 is exceedingly simple. A small magneto, or other generator having a straight line speed volts characteristic, is driven by a chain from the gas engine shaft. In circuit with the magneto is a rheostat *R* and a powerful iron-clad electromagnet *E*, which magnet is mounted on the frame composed of the side-pieces *D* having reach-rods joining in the bearings *J*, which bearings embrace the flywheel on either side. To the plunger *F* of the electromagnet are attached the two arms *G*, which form a toggle-joint acting on the hollow brake-shoe *B*, this shoe being water-cooled. The brake proper rests on a knife-edge *N* on the scale platform *M*; and a counterweight *K* on the back end of the toggle-joint serves to overcome the tendency of the brake-shoe *B* to fall inward against the wheel *C*. The thrust of the brake-shoe, due to the friction against the wheel, is taken up by the compression-arms *H* and communicated through the frame and knife-edge to the platform *M*. The turning moment, due to the friction of the bearings at *J*, is also indicated on the scale through the same point, so that there are no losses due to outside mechanism. Further, there are no strains on the engine shaft, because the thrust of the brake is taken up entirely by the bearings on either side of the flywheel.

The operation of the device is extremely simple. Briefly, the greater the speed of the engine, the greater the output in volts of the generator *S*; and the greater the voltage the greater the traction of the electromagnet *E*; and the greater the traction the more the thrust of the toggle-joint; with proportionate friction between the brake-shoe *B* and the wheel *C*. That is to say, the more speed the more volts, the more volts (by Ohm's law) the more amperes flowing in the electromagnet; and the more amperes the more friction; and the more friction the less speed. Therefore, by setting the rheostat *R* and the carbureter of the engine for any given load and speed, this brake will hold it constant for days at a time if necessary, the only limitation being apparently the efficiency of water-cooling of the brake-shoe. The power generated may be read off directly on a special scale-beam, or may be computed as with a Prony brake. The output of the generator *S*, as indicated on the voltmeter and ammeter, plus the known internal losses of the generator, must be

added to the brake readings to get the total power generated.

WESTERN SOCIETY OF ENGINEERS

Vol. 18, no. 8, October 1913, Chicago

The Decorative Possibilities of Concrete, C. W. Boynton and J. H. Libberton
Chicago Water Works, John Ericson (Abstracted)
Cooperation among Engineering Societies, Ralph D. Mershon

Vol. 18, no. 9, November 1913, Chicago

The Adaptation of Boiler Furnaces to Available Coals, Henry Kresinger and Walter T. Ray (Abstracted)
Chicago Subways
The Erection of the Municipal Bridge, St. Louis, W. H. Radcliffe

Chicago Water Works, John Ericson (36 pp., 17 figs. *dhs*). A partly historical description of the Chicago water works system.

The author discusses the question of metering the water delivered to customers, and shows that, while universal installation of meters is not advisable, if judiciously done, it will increase rather than diminish the city's revenues, irrespective of a decrease of pumpage. One of the important reasons why the existing plant is continually proving inadequate to meet the demand is the failure to adopt rational methods of water waste prevention. The fact that there is a large supply of water at the very door of the city does not mean that water should be considered as free as the air we breathe; it is shown that excessive pumpage does not benefit the people, and, in addition, when wasted, water escapes into the ground, and often becomes a detriment rather than a benefit.

In addition to the efforts for the conservation of the water delivered into the mains, a constant endeavor has been made to raise the efficiency of the plant. In this connection several interesting investigations had to be made. An accurate knowledge at frequent intervals of the amount of slip in the pumps was important, and for years, the records of pumpage had been based on plunger displacements and by estimate of the percentage of slip, if slip was considered at all. In order to obtain this information with reasonable accuracy, recording venturi meters were installed on the discharge mains of some new pumping engines, as well as many indicating and recording pitometers. In this way the condition of the pump valves of each engine is carefully checked at all times, and immediate repairs to or replacement of the same can be provided for when required. In another case considerable discrepancies appeared in the pressures reported from various pumping stations due to errors in pressure gages and elevations used in computing heads; for this reason a special design of mercury columns has been prepared, and will soon be installed in all pumping stations.

As regards the economy of operation of the pumping stations, a comparison was made between the Chicago plant and some private and municipally owned plants in other cities, on the following basis: The investigator determined the horsepower and the total amount of payroll of each pumping station, and from these deduced the number of horsepowers per dollar of daily payroll at each place (it is not stated on what basis the number of horsepower was obtained).

In the discussion which followed, objections to this basis of comparison were made since differences in the types, sizes and kinds of engines and operation under different conditions would lead to entirely dissimilar results. Henry A. Allen gave an insight into the conditions of operation at the Chicago pumping stations: in the city of Chicago at the present time, there are probably but three engines provided with suitable safety governors that, in the case of the bursting of a water main or of other cause tending suddenly to reduce the water pressure at the pumps, would stop the engines automatically and prevent them running away and going through the roof. As a matter of safety, more oilers are carried than would be the case were all engines of modern design and properly equipped; should anything happen, the oiler must be ready to jump to the throttle.

The Adaptation of Boiler Furnaces to Available Coals, Henry Kresinger and Walter T. Ray (60 pp., 17 figs. *epA*). The authors, in their work as fuel engineers of the Clinchfield Fuel Company, have been brought face to face with the fact that in certain districts of the South, owing to prevailing rates, only certain kinds of coal, mainly those with a highly volatile content, could be used, and the existing boilers did not appear to be fully adapted economically to take care of them.

The authors have therefore made an extensive series of tests in order to determine for water tube boilers (with tubes inclined slightly from the horizontal, having transverse gas baffles such as make the gases cross the tubes up, down, and up (three passes) whether by baffling the boiler horizontally and thereby obtaining a larger combustion space in the furnace, high volatile coal can be burned with good results; and whether, with the horizontal baffle, Pocahontas coal can be burned as economically as with the standard vertical baffle.

These tests were made in three series: The first series consisted of seven tests, and was made with the boiler baffled vertically, as it was installed by the maker (Fig. 18 A). The second series, also of seven tests, was made with the same boiler baffled horizontally in a way such that the space beyond the bridge wall was used as a combustion chamber, the burning gases passing lengthwise, first under the boiler, and then twice among the tubes, and out through the breeching. The third series, consisting of five tests, was made with the same boiler baffled horizontally in a way such that the gases passed lengthwise under the boiler as in the second series, then three times among the tubes, and finally under the steam drums and out through the breeching. All of the tests were run under the actual operating conditions. From a table giving the summary of results of his tests the author draws the following conclusions: Much better results can be obtained with Clinchfield coal when the boiler is baffled horizontally; there is also a marked improvement in the results in favor of the horizontal baffling when Pocahontas coal is used as fuel. The horizontal three-pass baffling gives the highest evaporation; the horizontal two-pass baffling gives the highest horsepower developed during the tests. With the two-pass horizontal baffling better evaporation and higher horsepower can be obtained with Clinchfield than with Pocahontas coal and the standard vertical baffling. The following additional remarks are of interest:

The boiler was run considerably above its rated capacity all the time. During regular operation the boilers would probably be operated most of the time below it, and would show a higher efficiency than that shown by the test. With

the present standard baffling of the boilers the greatest heat loss is in the chimney gases. During the last series of tests the author measured with an anemometer the velocity of air entering the ashpits of this boiler and also of boiler No. 1 which was equipped with the standard vertical baffles. It was found that on this boiler the velocity was about 450 ft. per min. On the other boiler it was about 800 ft. per min., or nearly twice as much, although only about two-thirds as

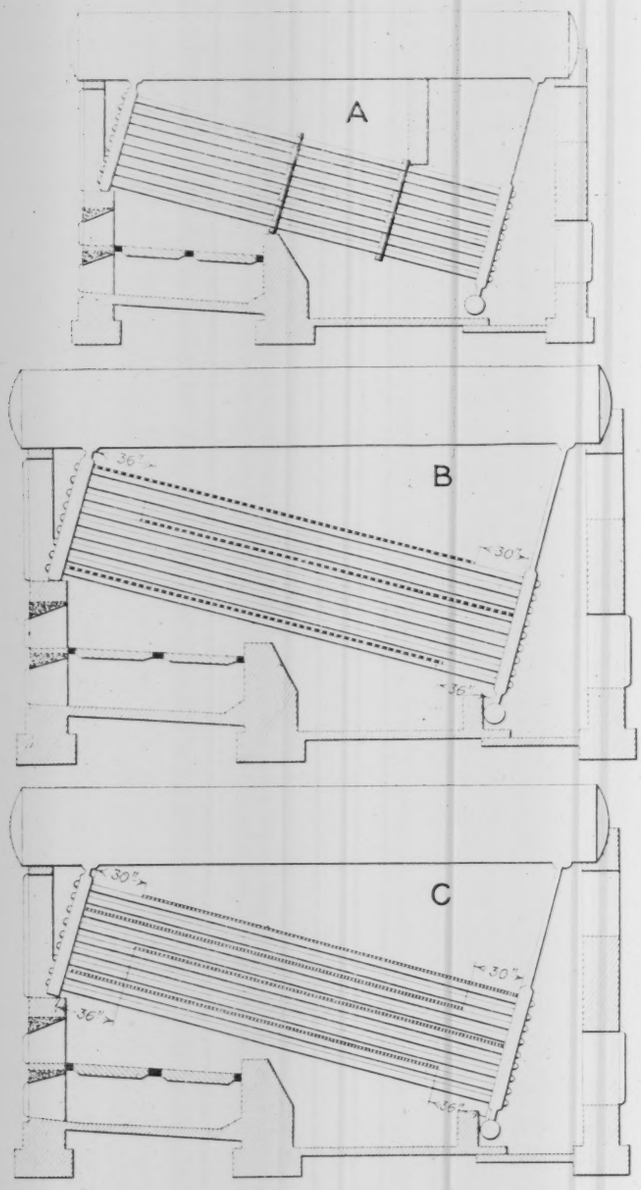


Fig. 18 Watertube Boilers with Various Types of Baffling

much coal was burned with the standard boiler as with the three-pass boiler. This velocity measurement showed conclusively that entirely too much air was used with the standard boiler. The area of the ashpit doors on both ashpits was the same. The approximate cost of materials for baffling with two horizontal passes is stated to be $57.25, and with three horizontal passes, $70.65.

In the discussion which followed, George H. Cushing, Mem.Am.Soc.M.E., called attention to the fact that the distribution of coal has so far been fixed by the freight rate charged the transit limit of the coal; hence the zone in which it would be sold has been pre-determined by transportation considerations, which are entirely outside both the coal and manufacturing industries. The mere fact of rearranging the coal-burning apparatus to suit the available fuel removes the railroad as the dominating influence, and substitutes for it engineering, which is far more an exact science than the rule-of-thumb now governing the rate-making function. For the coal industry, the adaptation of the boiler to the fuel used is of great importance because it will increase the demand for an exactly sized product, and that means introducing a manufacturing process for the purpose of giving to the consumer precisely the size and kind of coal he wants. That means also advancing the price, which is of less importance to the consumer after he learns to get full benefit of the exact sizing. For the boiler manufacturer to make a standard furnace and boiler setting is of course a very simple proposition; but the time has come when he will be forced to determine his factory problems mainly by consideration of how the buyers of his equipment can get power cheap. To do this, he will have to produce a flexible boiler-furnace setting that will give a proper mixture of coal gas and air while using any kind of coal, and if he does so he may add to the selling price of his iron and brick the price of high-class engineering service.

E. R. Fish gave a brief history of the Heine boiler in this country. The first Heine boiler was built in this country in 1882 by Col. E. D. Meier, Past-President of the Society, and to him is due the credit of having been the first to promote commercially the horizontal type of baffling.

T. A. Marsh, Mem.Am.Soc.M.E., pointed out how in the last five or six years the height from the header to the floor has gradually increased. In 1908, with a setting similar to that of Fig. A, a boiler was ordinarily set 7 ft. 6 in. from the header to the floor; and with proper draft, a sufficiently long arch, and furnace roof, a certain amount of smokelessness was obtained. The next year 8 ft. of height was considered to be necessary, and later on 8 ft. 6 in.; but 9 ft. was opposed both by the purchasers of the boilers and installers of equipment. Today a very good reason for installing boilers with less than 9 ft. 6 in. under the header has to be shown; and one of the large firms in the East has laid down the fixed rule that no Babcock and Wilcox type of boiler that they install shall be set with less than 12 ft. under the header; they are obtaining excellent results. Furnaces so designed are vertical, while those with tiled roofs are horizontal.

In the practice of the speaker, puddling of outside walls happened two or three times, and in order to avoid this kind of accidents, it is necessary that the lining in the two-pass boiler in the combustion chamber should be No. 1 fire brick.

E. A. Fessenden, Jun.Am.Soc.M.E., presented a table showing some points of comparison between the different methods of baffling employed in the tests. The draft loss through the boiler passages is less for the horizontal two-pass baffling than for the original baffling. The number of complete reversals of the gas stream is the same for the two cases, but two-pass horizontal baffling offers less resistance between the points of reversal. The resistance of the horizontal three-pass baffling is slightly greater than that with the original baffling.

FOREIGN REVIEW AND REVIEW OF THE PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

OWING to the wealth of material both in foreign periodicals and in the proceedings of engineering societies, some articles of interest had to be left unabstracted or abstracted only in part, to be taken care of in a later issue of The Journal.

THIS MONTH'S ARTICLES

A French military engineer solves the problem of safe flight by proposing a parachute that would protect both the aviator and his ship. A German engineer describes how a forge blower for duty, where reliability was the first consideration, was designed so that drawings and patterns of an old steam engine could be used in its construction. In the same section is reported an extensive investigation of a branched suction piping showing both the amount of air actually flowing through the various pipes in such a system, and the application of the Blaess method of equivalent openings to the design of large exhaustor systems.

In the section Internal-Combustion Engines, a calculation on the value of blast fuel and coke oven gas is reported, showing that with an output of less than 5,000,000 tons of pig iron per year, eastern and northern France disposes of a source of wealth in the coke oven and blast furnace gases, equivalent to approximately $24,000,000 per year. Tests of a peat suction gas producer are also reported: with poorly dried peat, the composition of the gas did not materially vary notwithstanding wide variations in load. Data on peat consumption are also given. Attention is also called to the inquiry started in France by *La Technique Moderne* on the operation of high efficiency heat engines. The important point of the predetermination of the dimensions of ports in two-stroke cycle oil engines is fully discussed. The author refers to what appears to be an interesting investigation of Kreglewski of which an abstract will be made as soon as the original text is received in this country.

The first part of the interesting article of F. Robin on case hardening is abstracted. Mr. Robin has done splendid work on heat treatment of metals and metallography and his opinions therefore are entitled to particular consideration.

The section Steam Engineering is especially rich in interesting material. O. Köchy reports a number of tests permitting of the establishment of the evaporation law for stationary boilers. Claassen describes a number of steam valves operated at a distance, by electric motors, electromagnets, water pressure surges, etc., as well as automatic mixing valves, constant pressure, constant temperature regulators, etc. Nerger gives data of tests made by the Prussian Railroad Administration in which locomotive smoke box cinders have been successfully burned under a boiler *without any addition of gas coal*. A description of the Missong engine, a single-cylinder compound engine with possibility of drawing-off receiver steam is given. The status of the steam turbine is being established in Germany, and Professor Josse draws a picture in bold lines, from data obtained from replies to a circular letter sent out by him to a number of turbine-driven central stations, showing the direction which the development of steam turbine engineering took there.

Wm. H. Kaempfer presents a full compilation of data with respect to air seasoning of timber. James P. Gillies, before the American Society of Brewing Technology, discusses the subject of compressed air pumping on the air lift system, on which, unfortunately, comparatively little information is available in an easily accessible form. E. N. Janson shows why marine shafting may sometimes be severely overstrained, even though apparently designed with proper margins of safety. H. C. Johnson, in a paper before the Concrete Institute, reports the results of tests on the Strength of Cement, while from a paper of the South African Institution of Engineers is abstracted an interesting discussion of the much neglected subject of saving of air power in the rock-drill operation.

Abstracts of articles on radium pyrometers, artificial rubber from coke oven gas, subway elevators, etc., will be found in various sections of the Survey. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated A by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

Aeronautics

AN AVIATION PARACHUTE (*Un parachute d'aviation*, E. C. *Revue industrielle*, vol. 44, no. 2112-47, p. 655, November 22, 1913. 1 p., 2 figs. *d*). A parachute must satisfy the following requirements: (*a*) when folded it must not affect the operation of the airship, which in turn must not hinder the unrolling of the parachute; (*b*) its unfolding must not produce effects of inertia dangerous for the aviator or for the safety of the parachute suspension, and (*c*) it must unfold fast enough to be available for use with comparatively small elevations. Captain Couade, of the French army, in conformity with these principles, designed *a parachute for saving both the aviator and the ship*. The parachute 1 (Fig.1) is enclosed in a tube 2 placed so as to open behind the rudder, and is provided at its end with a small tractor parachute 3, which alone projects from the tube. Usually this tractor is kept folded, but may be very rapidly opened by a single motion of the aviator. When opened, it draws the large parachute out of its sheath, and places it along the wind stream line. The area of the large parachute is calculated so as to give a velocity of descent of 6.50 m. To avoid excessive accelerations produced by the unrolling of the parachute when the ship is moving at great speed, a cable 4 is interposed between the suspension proper and the aeroplane, and a brake 5 is set in a manner such that the acceleration should not exceed a certain predetermined value; a shock absorber 6 affords the apparatus a still further protection from breakages due to too rapid action of the brake. When the tractor parachute 3 opens, it unrolls at first only a part of the large parachute, as shown by full lines; then the pressure of the air on 1 causes the string 7 to break, and the entire parachute unrolls. This gives to the parachute a more even action, and prevents excessive

gliding. Tests made with models have shown that the apparatus acts in a satisfactory manner. For speeds between 15 and 21 m (49.2 and 68.8 ft.), it has been found in two cases that the accelerations were in excess of

$$A_o = g\,\frac{Kr^2V^2 - (P+p)}{P+p+1.92gKr^2}$$

where A_o is the decelaration produced by the air on a projectile, according to the formula of Didion.

Air Machinery

Forge Blower (*Gebläse für Schmiedefeuer,* O. Klepal. *Die Fördertechnik*, vol. 6, no. 11, p. 262, 1½ pp., November 1913. 2 figs. *d*). Description of a curious forge

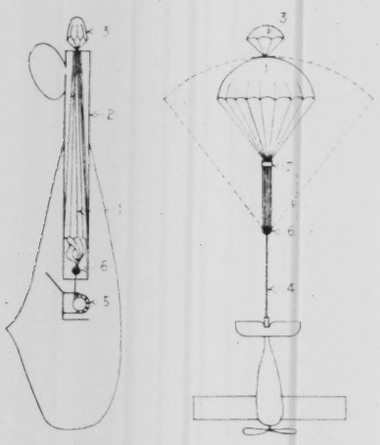


Fig. 1 Couade Parachute

blower in the construction of which were used, with only slight modifications, patterns and drawings of an old type steam engine designed for 8 atmospheres gage pressure. The blower was to be used in connection with the continuous production of hardened steel balls, and any interruption, either for repairs or adjustment, would be extremely inconvenient. In view of this, a very low volumetric efficiency (0.80 per cent) has been selected, so as to avoid as far as possible leakage at the valves. The use of the old steam engine drawings and patterns permitted the production of the blower at a saving of 13 per cent against what it would have cost otherwise.

Investigation of Air Distribution in a Branched Piping of an Exhauster Plant (*Untersuchung über die Luftverteilung einer verzweigten Exhaustoranlage,* D. Eie and H. Ovenberg. *Zeitschrift des Vereines deutscher Ingenieure,* vol. 57, no. 49, p. 1943. 3 pp., 4 figs. *eA*). Wherever a system of branched piping is required for the delivery of liquids, gases, and air to several places from a common source, the designing engineer has to determine the dimensions of the various pipes in a manner such that they might be able to carry the desired quantities at the given pressure head. This problem is often most important owing to the fact that once a system has been laid, there is very little chance for changing it if it should prove unsatisfactory.

The present investigation is of interest in view of the lack of published data concerning large exhauster systems carrying air at the average temperature and average pressure. The system described in the present article forms part of a large wood-working plant and has to carry out shavings and sawdust from the wood-working machines and metal dust from the fettling shop. The shavings and sawdust are taken up by the catcher at the place of origin, thoroughly mixed with air and drawn into the pipe where they are carried away on account of the large air velocity existing there.

The suction system, Fig. 3, consists of three main lines into which at various places lead 18 side lines. The three main lines unite shortly in front of the exhauster, from which extends a pressure pipe 16 m. (52.4 ft.) long and 500 mm. (19.6 in.) wide to the main pump. In order to avoid excessive pressure losses, the branches are connected to the main suction pipe at as small angles as possible. The experiment was carried on with pure air, all the machines standing still. During this investigation, the part from the quarter bend *a* to the pump was cut out, all the pipes were carefully cleaned, and the measurements made at the places indicated in the illustration by numbers enclosed in circles. In order to calculate the amount of air flowing through the main lines and through separate branches, the velocity was in each case measured at five points equally distributed over the cross-section of the pipe and the average velocity determined therefrom. The Krell dynamic disc, Fig. 2, was used for the measurement of velocity. In this apparatus there are two places at which the disc pipes join the manometer, so that the influence of static pressure is eliminated and the manometer indicates only the pressure difference proportional to the velocity head. In order to determine the constant α of the dynamic disc as given by the equation $v = \alpha\sqrt{H_{st}}$, the author has measured the air flowing through a piping system by means of calibrated nozzles and found that the average value of the constant α is equal to 3.17. The velocities were determined by means of a micromanometer indicating pressures enlarged 9.7 times. Table 1 indicates the results of the in-

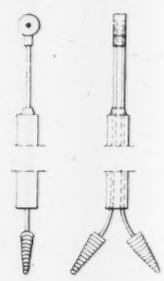


Fig. 2 Krell Apparatus for Measuring Air Velocities

vestigation and shows the amount of air flowing through the various pipes. The values given in the last line were found by comparing the average values obtained directly from air measurements in front and behind the exhauster with the total quantities of air sucked in, and the difference was distributed to the various branches in proportion to their part in the operation of the system. It is interesting to note that the quantities as actually determined by measurement differ but little from those calculated. The measurement indicates at some places velocities too low for the proper operation of the plant. This is, however, of no practical importance since, when the plant is actually operated, the branches do not all work at the same time, as was done during the test,

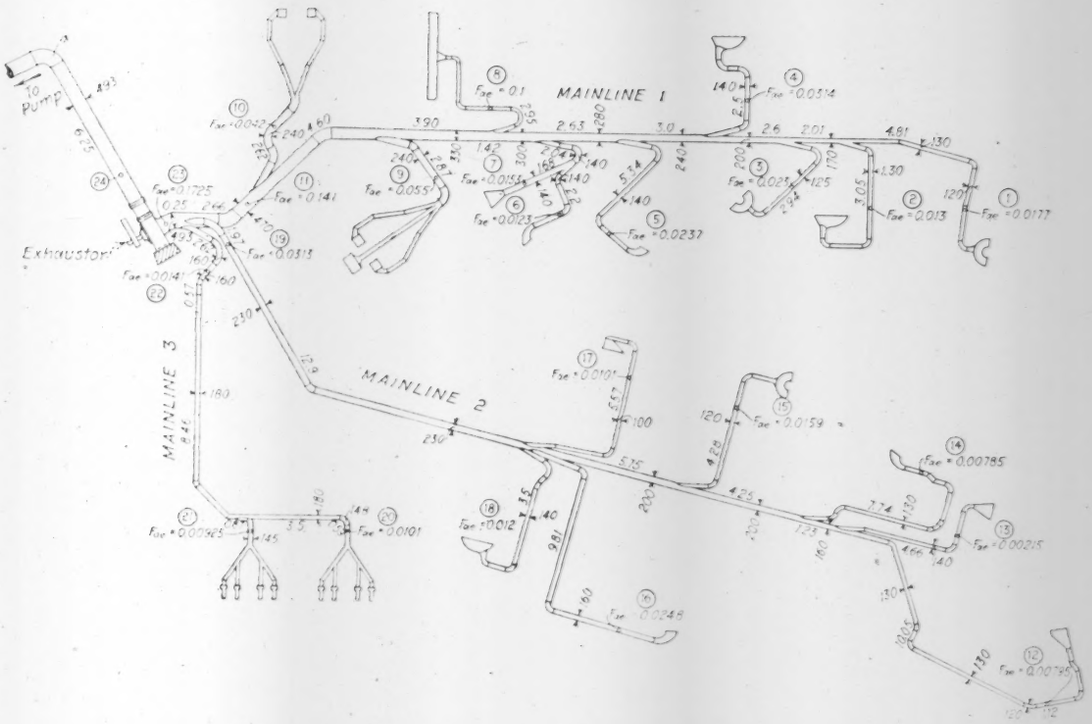


Fig. 3 Branched Piping for an Air Suction System, Piping Plan

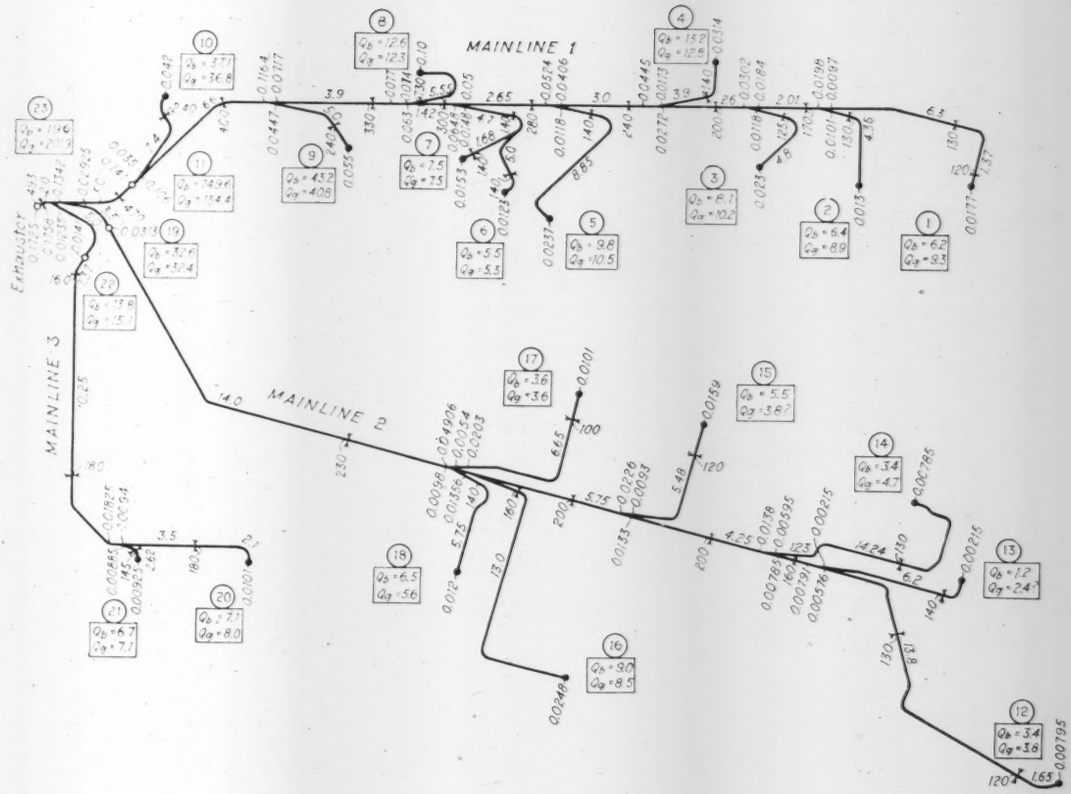


Fig. 4 Same System as in Fig. 3, with the Indication of equivalent lengths of pipes

TABLE I BRANCHED EXHAUSTOR SYSTEM

Point of Measurement	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Diameter D ....mm.	130	130	125	140	140	140	140	130	240	240	470	130	140	130	120	160	100	140	230	148	145	166	493	498
Diameter D ....in.	5.2	5.2	5.0	5.6	5.6	5.6	5.6	5.2	9.55	9.55	18.8	5.2	5.6	5.2	4.8	6.4	4.0	5.6	9.2	5.91	5.65	6.4	19.7	19.65
Manometer (velocity measurement)	127.4	114.8	181.4	176.8	121.4	30.0	60.2	218.8	208.6	169.6	210.0	24.0	7.2	1.49	1.34	2.1	2.55	1.58	6.47	2.38	2.8	5.98	12.2	11.8
H_{st} measured ....mm. water	13.14	11.83	18.7	18.2	12.5	3.09	6.2	22.55	21.5	17.5	21.6	2.47	0.74	3.89	3.45	5.4	6.6	4.07	16.5	6.17	5.35	15.4	31.5	30.2
Average velocity $v = 3.17\sqrt{H_{st}}$ ....m./sec.	11.5	10.9	13.7	13.5	11.2	5.6	7.9	15.05	14.7	13.25	14.7	5.0	2.73	6.25	5.9	7.4	8.15	6.1	12.9	7.9	7.3	12.4	17.8	17.4
Average Velocity $v = 3.17\sqrt{H_{st}}$ ....ft. per sec.	37.8	35.8	45.0	44.2	36.8	18.4	26.0	49.5	48.2	43.5	48.2	16.4	9.0	20.5	19.4	24.2	26.7	21.0	42.3	26.0	24.0	40.7	58.5	57.1
$Q = 60\frac{\pi}{4}D^2v$ ....cbm./min.	9.1	8.7	10.0	12.5	10.3	5.2	7.3	12.0	39.9	36.0	153.0	4.0	2.5	5.0	4.0	8.9	3.8	5.9	32.1	8.1	7.2	15.0	204.0	203
Calculated volume of air Q_g ....cbm./min.	9.3	8.9	10.2	12.8	10.5	5.3	7.5	12.3	40.8	36.8	151.4	3.8	2.4	4.7	3.8	8.5	3.6	5.6	32.4	8.0	7.1	15.1	201.9	201.9

while it has been experimentally established that the velocity of air in the branch pipes rises materially when the suction system is only partly opened. This explains why actually the system operates in a satisfactory manner.

The investigation of this plant afforded an opportunity to test the process of Blaess for the calculations of branched piping. The fundamental idea of the Blaess process is in the use of equivalent openings and their connection in series and in parallel. By an equivalent opening of a pipe or system of piping is meant the area of such an opening, free from contraction, which at the given pressure would permit the same amount of fluid to pass as the entire system of piping. The action of the system of piping is therefore characterized by the equivalent area instead of by the pipe friction and inlet or outlet resistance. This equivalent opening in the case of a given pipe has a practically constant value for all velocities occurring in actual practice. If the piping has no inlet or outlet resistance, the equivalent opening $F\rho$ represents only friction. On the other hand, when friction is neglected, the equivalent opening of the pipe F_s is a function of only inlet and outlet resistance. For a given pipe system, these equivalent openings may be combined as shown by the following equation:

$$\frac{1}{F_{ae}^2} = \frac{1}{F\rho^2} + \frac{1}{F_s^2}$$

At the places where two or more branches come together, their equivalent openings may be added, since there can be only one common pressure. Since the branch pipings work in conjunction with various machines and are provided with catchers of very different types, of which the equivalent openings could not be theoretically determined, we have determined these equivalent openings from the following equation:

$$Q = 60F_{ae}\sqrt{H_u} \text{ and } F_{ae} = \frac{Q}{240\sqrt{H_u}}$$

Where H_u represents the total pressure, or as in this case a partial vacuum at the place of measurement; in order to determine the equivalent openings of the various catchers with the pipes in conjunction with them, it is necessary to determine by measurement the velocity head and partial vacuum. In order to obtain as exact figures as possible it is desirable to work with high pressures and wide manometer variations. To do this, the author when measuring at one pipe closed all the others, the measurements being made as before at five different points of each cross-section and the average value taken. These equivalent openings are indicated in Fig. 3.

In Fig. 4 geometrical axes of the pipes with the equivalent lengths of the various pipes are indicated, to the actual length being added certain supplementary lengths, namely: for a quarter bend of 9 deg. a length equal to 10 diameters; for bends of smaller or larger angles correspondingly smaller or larger additions. The equivalent openings are also marked.

From these figures, it appears that the equivalent opening of the entire suction piping directly in front of the exhauster is equal to 0.1725 qm. (1.845 sq. ft.) with a partial vacuum of 22.3 mm. (0.876 in.) of water. The quantity of air taken in by the exhauster is equal to

$Q_b = 60F_{ae}4\sqrt{H_u} = 196$ cbm/min. $= 6818$ cu. ft./min.

which agrees fairly well with the 201.9 cbm/min. as determined by direct measurement. If it is desired to determine the quantity of air flowing through any of the branches, it is

necessary only to divide 196 cbm/min. in proportion to the ratio of equivalent opening of the pipe under consideration to that of the entire system. In Fig. 4, the quantities so calculated Q_b and the quantities Q_e actually measured are indicated at the various branches of the system.

It may also be of interest to establish the distribution of the partial vacuum in this system by using the calculated quantities of air delivery and the velocities obtained thereby, and by calculating the partial losses in the various pipes from the formula:

$$Hp = \lambda \frac{l}{D} \frac{\gamma v^2}{2g}$$

The sums of all these partial pressures from the exhaust to each of the ends of the system must be equal, namely: 22.3 mm. of water. In this connection the inlet resistance indicated in Fig. 4 must not be left out of account. The author has made all these calculations which he gives in a special table and which show that the values calculated come fairly close to the expected value 22.3 mm. (0.876 in.) of water. On the whole, the calculated values agree fairly closely with those determined by actual measurement, with the exception only of branches working at very low velocities where the discrepancy may have been due to the imperfections of the water manometer.

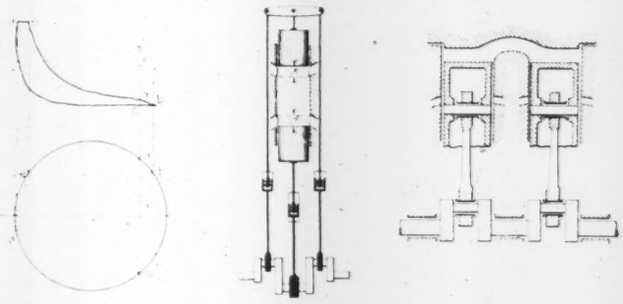


Fig. 5 Fig. 6 Fig. 7

Fig. 5 Indicator Diagram of a Two-stroke Cycle Oil Engine
Fig. 6 Diagrammatic View of a Junkers Engine
Fig. 7 Diagrammatic View of a Toussaint Engine

Hoisting Machinery

Elevators at the Stations "Abbesses" and "Lamarck" of the North-South Electric Railway in Paris (*Les ascenseurs des stations "Abbesses" et "Lamarck" du chemin de fer électrique Nord-Sud de Paris*, H. Brot. *Le Génie Civil*, vol. 44, no. 6, p. 107. 5 pp., 14 figs. *d*). At some of the stations of the North-South Electric Railway in Paris cage type elevators are used, at the Pigalle station escalators of the Hocquart type. The present article describes the former. Each station is provided with two cages running in parallel shafts. Each cage has, in addition to the usual two doors, for entrance and exit, an emergency door by means of which the two cages may be connected with one another. If for any reason, therefore, one of the cages should be stuck between floors, the passengers would not have to be kept locked in until the defect was repaired: all that is necessary is to bring up the other cage, empty, to the proper level, open the emergency doors and transfer the passengers. After a careful study, a nearly semicircular shape was adopted for the cabins because it was found that that form accommodated the largest number of passengers for the given floor space. The lifting gear consists of a drum with four screws, driven by two electric motors. The total weight of the cage with passengers being about 12 metric tons (say 13.1 short tons), it was thought advisable to lighten the stresses in the transmission from the motors to the drum by dividing the worm gear corresponding to each motor, into two symmetrical units, with gear wheels in mesh with one another but rotating in opposite directions. Owing to this arrangement there is no thrust along the motor axis, so that thrust bearings could be dispensed with. If a tooth in a gear wheel should break, the connection between the motor and the drum would not be broken. The "triple-grip" safety device is used, to protect the cage from excessive speeds.

Internal Combustion Engineering

Calculation of Length of Passages in Two-Stroke Cycle Oil Engine having Distribution by Means of Ports (*Berechnung der Kanallängen von Zweitakt-Ölmaschinen mit Schlitzsteuerung*, O. Föppl. *Zeitschrift des Vereines deutscher Ingenieure*, vol. 57, no. 49, p. 1939, December 6, 1913. 5 pp., 8 figs. *mt*). An important point which must be considered in the design of two-cycle oil engines is the correct dimensioning of exhaust and admission slots. This matter is comparatively simple in the case of four-cycle engines where there is a full stroke available for the exhaust and another one for filling the cylinder with fresh air, but in two-cycle engines the requirements are much more strict, as at the point *a* (Fig. 5) at the end of the expansion the exhaust of gases begins. As soon as the pressure has sufficiently gone down, namely at *b*, the entrance of fresh air begins which is expected to drive the rest of the gases of combustion out of the cylinder and provide the necessary oxygen for the next combustion (the Diesel process is here considered). At *c* the charging process is considered finished and the compression of the fresh air begins, while at *d* the compression is ended, or nearly ended, and the admission of the fuel begins, continuing at constant pressure up to the point *e*. Thus the exhaust and charging processes must be fully accomplished within the brief period from *a* to *c*, which on the crank diagram represents only 90 to 120 deg. as against 360 deg. in the four-cycle engine.

Every unnecessary increase of the angle between *a* and *c* decreases the useful stroke of the engine and therefore its output and mechanical efficiency. On the other hand, if too much saving in time is attempted and the exhaust lead *a-b* is made too small, there is danger that the exhaust gases will flow back into the fresh air and pollute it; at the same time, too short a period of scavenging necessitates

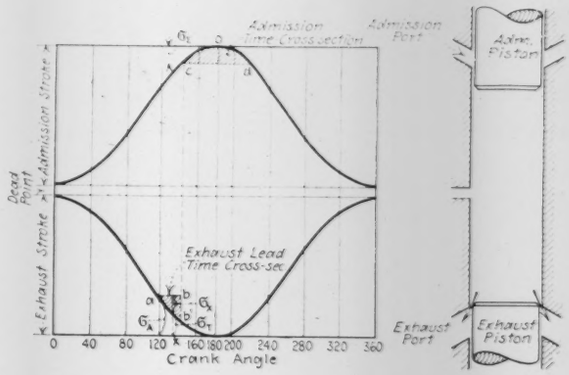


Fig. 8 Crank Path Diagram for a Junkers Oil Engine

driving the fresh air at too high a pressure which may lead to excessive consumption of power at the scavenging pumps. For example, in the early engines the scavenging took as much as 15 per cent. of the indicated power, while with proper dimensions of ports it ought to take only 3 per cent to 6 per cent.

All these considerations apply only to engines having distribution by means of ports, in particular to double-cylinder engines in which admission and exhaust are regulated by one of the pistons respectively.

Fig. 6 shows a Junkers engine of the present type with opposite pistons acting on a two-throw crankshaft. Fig. 7 shows what is called a Toussaint engine with pistons in parallel, one acting on the admission port and the other on the exhaust port.

The problem of the present investigation is to determine the processes of equalization of pressure which take place at the opening of ports. Two vessels, the cylinder and exhaust space, or the compressed air container and the cylinder, are filled with gases at different pressures, different temperatures, and having different specific gravities and for a certain time are connected by the ports. The problem is to determine quantitatively the process of equalization of pressure due to the flow of gases from the higher pressure level to the lower. This problem would have been comparatively simple if the shape and cross-section of the ports remained constant, in which case the flow of the gases during the opening would be proportional to the time-cross-section. In the present case, however, the section of the port varies from zero to maximum and back to zero again. One has therefore, to consider what happens during an infinitesimally short period dt. During dt there is available to the flow of gas a time-cross-section Fdt, while the quantity of gas or air which flows during the time period dt is

$$dG = F.\ dt.\ \gamma\ v\ f\ (p_1,\ p_2,\ T) \ldots\ldots\ldots\ldots [1]$$

where v is the coefficient of contraction, γ specific weight, and $f\ (p_1,\ p_2,\ T)$ is a function of pressure p and temperature T which, for particular cases may be determined from the theory of flow of gases. The total quantity of gas G which passes through the port during the entire period of the operation of the process of pressure equalization is therefore

$$G = \int_{t=0}^{t} F.\ dt.\ \gamma\ v.\ f\ (p_1,\ p_2,\ T) \ldots\ldots\ldots [2]$$

The members under the integral sign all vary with time. The exact determination for the exhaust and admission processes in the oil engine has been indicated by Kreglewski in his book [cp. also his articles in the *Oilmotor* (end of 1913 and in 1914)]. By the methods indicated by him and in view of the fact that there are plenty of data for the determination of the value of v, it is possible to determine the correct dimensions of the admission and exhaust ports just as Kreglewski has done for the oil engines of the German General Electric Company.

Kreglewski, however, assumes that the magnitude of the contraction coefficient v for the temperature under consideration and the shape of port is known. In the present method, the method of similarity is used, it being assumed that experiments have been made to determine the exhaust and admission processes in a certain engine and that it has been established for what speed the exhaust and admission ports have been properly dimensioned; then by the method of similarity the proper dimensions of the ports for every other engine may be determined. Two engines are of different dimensions of cylinders, length of stroke and speed. Nevertheless, when the exhaust port is opened, under the assumption of normal load, the pressure, temperature, and specific weights of the exhaust gases in both engines will be approximately equal, but owing to the flow of exhaust gases from the ports, the state and quantity of the gases in the two cylinders vary, and with very considerable approximation, we may assume that the state of the gases in the two engines varies equally, or that at points of equal pressure, equal temperatures and equal specific weights prevail in both cases. The average velocity in the exhaust passages depends on the difference of pressure in the cylinder and the exhaust tank, the temperature and the specific weights of the exhaust gases, and the coefficient of contraction, which last may be assumed to be equal in both cases. Then at the points of equal pressures and at proper instants of time may be obtained equal velocities in the passages or, which means the same thing, the quantities of gases flowing per second would be at these time-instants proportional to the free sections of the passages.

Now it is clear how the "corresponding points" in the two engines are obtained. The amounts of gases flowing out at the points of equal pressure are in the first place proportional, under the assumption above made, to the quantities of exhaust gases initially present and, on the other hand, they are proportional to the free time-cross-sections $\int Fdt$ of the passages, which means that in these points the value of $\int Fdt$ for both cylinders is proportional to the initially present quantities of exhaust gases, or approximately, to the volume of cylinder swept by piston. The admission ports should be opened (point b) as soon as the pressure of the exhaust gases has reached an appropriate value. The time-cross-section for the exhaust lead (points a to b) has therefore to be made proportional to the volume of cylinder swept by the piston V, or

$$\int F_1 dt : \int F_2 dt = V_1 : V_2 = \frac{D_1^2 s_1}{D_2^2 s_2} \ldots\ldots [3]$$

where F are the variable ports, s the strokes, V the volumes of cylinders swept by the piston, and D the diameters of the cylinders of the two engines.

Similar considerations apply to the charging process. Here it is assumed that at the beginning of the opening of the admission ports the pressures of the exhaust gases in the cylinders of both engines are equal and the conditions of the equation just preceding are therefore satisfied. The condition of equal scavenging relations in both engines takes, therefore, also the form of the preceding equation where $\int Fdt$ represents the time-cross-section for the charging port. The meaning of the integral $\int Fdt$ and the method of its determination requires some further explanation. F is the free cross-section of the port at the instant t and is equal to $\xi D \pi s_x$, if by s_x be denoted the free

distance from the regulating edge of the piston to the regulating edge of the port, and by ξ is denoted the ratio of the sum of the widths of ports to the circumference of the cylinder. The simplest way to determine the value of the integral is by means of a crank path diagram, such as is drawn in Fig. 8 for a Junkers engine. On the horizontal axis are represented the crank angles α which represent also time, since the angular velocity is constant. On the Y-axis are indicated the corresponding piston positions. In a the exhaust passages are opened by one piston; at the time x they are opened to the extent of $s_A - s_1 = s_x$, where s_A is the maximum opening of the port, and s_1 the distance of the piston from the dead point. The total time-cross-section $\int Fdt$ for the exhaust lead is represented by the area abb'; which, on account of the scale used, has to be multiplied by $\xi D\pi$. In c the regulating edge of the other piston passes the admission port. The area cod is the useful time-cross-section for the charging process, and the author shows that the two integrals which express the time-cross-sections of the two engines (in stroke-percentages times crank angles) are to one another in the same ratio as the respective products of the cylinder diameters by the speed in revolutions. The part of the stroke which has to be sacrificed for the admission and exhaust processes, increases therefore, for the same processes, with the diameter of the engine and its speed in revolutions, and, consequently, the expression $\frac{\int \sigma_x d\alpha}{D_n}$ is a constant for all engines with properly dimensioned ports, and is denoted by C_E for admission and C_A for exhaust. If the dimensions of the ports (C_E and C_A) have been determined (e.g. by tests) for one engine, the dimensions of the ports for all other engines may be derived therefrom.

Equations [7] and [9] permit the proper length of ports to be obtained for any conditions. In all practical cases, the deviations from the exact graphical determinations in accordance with equations [4] and [5] do not exceed 3 per cent and are therefore really so small as to be hardly worth considering even in the final design. Attention must be called here to certain assumptions which have to be taken into consideration in the final application of this formula. As was mentioned above, it is assumed that approximately 25 per cent more fresh air is blown into the cylinder than is actually required for compression and combustion. This excess of air is obtained by making the volume of cylinder swept by the piston of the charging pump 1.35 to 1.45 times as large as that of the corresponding working cylinder. The admission ports are then proportionally dimensioned if the average pressure in the scavenging tank at the average speed of the engine is 0.08 to 0.12 atmospheres. If in the case of any engine in which the admission ports have been calculated in accordance with equation [7], a different pressure is used in the scavenging tank, the dimensions of the passages have to be correspondingly changed in accordance with the value of the C_E for the latter case. The value of σ_A is determined by the initial pressure at the beginning of the exhaust, which is to a certain extent proportional to the average indicated pressure p_i. Since this average indicated pressure in the case of two-cycle engines varies between 6 and 10 atmospheres, the final selected value of C_A must be always brought in accord with this average indicated pressure. The pressure of the exhaust gases in the cylinder at the opening of the admission ports should, if the passages have been properly dimensioned, amount to 0.3 to 0.5 atmospheres, which is sufficient to prevent the back flow of exhaust gases into the charging air.

For example, in an engine in which the pressure of the exhaust gases at the opening of the admission ports amounted to as much as 0.8 atmospheres out of the total mass of the exhaust gases only three to four per cent have come back into the charging air as has been established by means of diagrams and analytically. Such a small amount will be most likely forced out for the most part by the excess of air, which shows that even a back pressure of 0.8 atmospheres does not cause any serious pollution of the charging air.

The author shows further how to apply this formula to the case of a single-piston engine.

Gas Cleaning According to the New Theisen Process (*Die Gasreinigung nach dem neuen Theisenschen Verfahren, Stahl und Eisen*, vol. 33, no. 51, December 18, 1913, 7pp., 12 figs. *de*). During the last few years a new type of the Theisen gas washer of the disintegrator type has been placed on the market. In several places careful tests of its efficiency have been made. At the Differdinger metallurgical plant a large Theisen disintegrator with a water separator has been installed at the end of 1912, and is at work since then continuously. This disintegrator was designed for preliminary cleaning of blast-furnace gas at the rate of 40,000 cbm. (1,412,580 cu. ft.) per hour from a dust content of 4 grams per cbm. (1.736 grains per cu. ft.) to 0.3 to 0.5 (0.1302 to 0.2170 grains per cu. ft.). As a matter of fact, however, the gas as it came from the furnace had a dust content of only 0.88 to 1.46 grams per cbm., and the output of the disintegrator as regards the purity of the gas was therefore even better than the guarantee. Several hundreds of tests have been made with this disintegrator in order to determine its best efficiency at various pressures and with various amounts of water.

The power consumption as given in Table 2 includes a comparatively high suction and pressure, and would be considerably lower with smaller pressure variations.

At the Rombach metallurgical plant in Rombach two Theisen disintegrators with an output of 30,000 cbm. (1,059,430 cu. ft.) per hour have been at work, one continuously for 14 months. Not long ago careful tests of output were also made there and the results are given in Table 3. In Rombach the output has been measured by three different methods, first by a hydro apparatus specially calibrated for this purpose; next by a Rabe tube, and finally by means of a gasometer of 4000 cbm. (141,258 cu. ft.) capacity and 80 mm. (3.14 in.) of water pressure. The fact that the pressure of disintegrator 2 is less than that in disintegrator 1 is explained by the presence in the former of a washing surface built concentrically around the pressure fan for experimental purposes. The higher power consumption (about 10 h.p.) in disintegrator 2 is due partly to greater amounts of water and also to the presence of the above-mentioned washing surface, which may be considered partly recovered in the way of greater cleanness of the gas. The temperatures show that with nearly equal

TABLE 2 TESTS OF A THEISEN DISINTEGRATOR IN DIFFERDINGEN

Gas Volume referred to 50 Deg. Cent. (122 Deg. Fahr.), cbm cu.ft. per hr.	Gas Pressure: In Suction Pipe in Front of Washer, mm of Water	Gas Pressure: Between Water Separator and Washer, mm of Water	Pressure Rise, mm of Water	Dust Content in Gas, g cbm: In Front of Washer	Dust Content in Gas, g cbm: After Passing Washer	Gas Temperature, Deg. Cent. Fahr.: In Front of Washer	Gas Temperature, Deg. Cent. Fahr.: After Passing Washer	Temperature of Water, Deg. Cent. Deg. Fahr.: In Front of Washer	Temperature of Water, Deg. Cent. Deg. Fahr.: Behind Washer	Water Consumption, 1 cbm and gal cu. ft.	Total Power Consumption, h.p., per 1000 cbm cu. ft.
44327 1,571,742	−70.5	130.3	200.8	1.08	0.020	40.0 104	40.5 104.9	30.86	39.3 102.8	0.684 0.00513	5.55 0.157
47353 1,672,245	−90	150	240	1.0	0.012	32.5 90.5	33.5 92.3	29.84.2	33.91.4	0.555 0.00416	5.43 0.154
48515 1,716,460	−85	153	238	0.944	0.018	33.3 92	34.5 94.1	29.5 85.1	33.8 92.8	0.550 0.00412	5.22 0.148
46611 1,649,539	−85	158.3	243.3	0.880	0.008	32.5 90.5	33.5 92.3	29.84.2	33.91.4	0.430 0.00322	5.00 0.142

TABLE 3 DATA OF TESTS OF A THEISEN DISINTEGRATOR AT ROMBACH

(Arrangement of Data same as in Table 2)

30252* 1,068,963	−30.0	196.5	226.5	0.22	0.014	29.84.2	31.87.8	27.0 80.6	30.4 86.7	0.549 0.00411	4.1 0.116
40312* 1,074,261	−22.9	137.1	160.0	0.35	0.016	30.6 87	31.3 88.3	26.4 79.6	30.8 87.4	0.699 0.00524	4.5 0.127
33050* 1,520,288	−55.0	130.0	180.0	....	....	....	....	....	....	0.387 0.00290	2.9 0.082

* Referred to 20 deg. cent. (68 deg. fahr. and 760 mm pressure)

entrance temperature of the gas and water there is a slight rise of the heat in the water and the gas, originated partly by conversion of work in the washer into heat.

Another disintegrator of the countercurrent type is now at work in an Austrian metallurgical plant. There a very interesting comparison was made between a Theisen disintegrator and a disintegrator of the Schwartz-Bayer system. Both cleaners take the raw gas from a common pipe and send the cleaned gas into a common pipe again. The dust content of the raws gas, the pressure of the latter, and the pressure in the cleaned gas piping are therefore equal for both apparatus. The output and power consumption in both apparatus are also practically equal, while the water consumption and the degree of cleanness are shown by Table 4. These experiments tend to show that the Theisen disintegrator under equal conditions of operation as compared with the Schwartz-Bayer disintegrator works with about one-half water consumption and about ten times higher degree of cleanness. As regards space requirements and reliability of operation, the Theisen disintegrator is also materially better than the other type, since it requires only a direct coupled 125-h.p. motor, while the other type requires two motors of 35 h.p. each for the disintegrator and another motor of 60 h.p. for a separately driven fan.

Artificial Rubber from Coke Oven Gas (*Le caoutchouc artificiel extrait des gaz de four à coke*, in *Economies réalisables dans l'Est et le Nord de la France par l'utilisation des gaz des fours à coke et des hauts fourneaux*, A. Gouvy. *Société industrielle de l'Est*, no. 114, p. 45, November 1913. 54 pp., 19 figs. *d*). In an article describing various applications of coke oven and blast furnace gas, and apparatus for utilizing them, the author mentions also a German patent obtained by the Tar Utilization Company (Teerverwertungsgesellschaft) of Duisburg, Germany, for producing artificial rubber from coke oven gas. The processes of Bayer and others are based on the manufacture of a hydrocarbon called butadene, and converting it into isoprene, from which rubber is developed. The new process is based on the fact that in coke oven gas there is already a certain amount of butadene present; benzole is submitted to fractional distillation, of which the products are then kept for a certain length of time in contact with sodium; the latter causes the precipitation of the sodium compounds, and the subsequent polymerization of the other hydrocarbons, which may be intensified by the presence of small quantities of ammonia. The rubber obtained is said to be good, but the cost of the process is yet high.

TABLE 4 COMPARATIVE TESTS OF A THEISEN AND A SCHWARZ-BAYER DISINTEGRATOR

	Water Consumption, g cbm	Cleanness of Gas, g cbm
Theisen disintregator	0.7—0.9	0.03—0.06
Schwarz-Bayer disintegrator	1.3—1.5	0.3—0.5

The author attempts to estimate the value of the blast furnace and coke oven gas obtained in Eastern and Northern France, where 4,480,000 tons (metric) of pig iron are produced. This corresponds to an output of coke of 4,480,000 metric tons per year, or 511.3 tons per hour, which, at the rate of 4500 cu. m. of gas per ton of coke, gives (after the deduction of 40 per cent for the Cowper blast heater and 10 per cent of what remains for the blower) 1,242,459 cu. m. per hour. This, at 0.04 franc ($0.008) per kw-hr. and 5000 hours per year, corresponds to an output representing 53,300,000 francs ($10,697,000) per year. This leaves 3760 hours in which the gas is supposed not to be utilized for power purposes, but might be so utilized for by-product manufacture, e.g., the production of nitrates or nitric acid. A similar calculation is made for the coke furnaces. With a demand for approximately 510 tons per hour of coke, and a coking efficiency of about 75 per cent, 680 tons of coal have to be treated per hour, with a pro-

duction of gases 190,400 cu. m. One half of this output of gas will be consumed by the furnaces themselves, while the other half corresponds to 104,000 kw., which, for 5000 hours of operation per year, are worth 20,800,000 francs ($3,952,000). There remains still the output of 3760 hours, which may be used either for chemical manufactures or for lighting, the gas in either case having a value of approximately 0.03 franc ($0.006) per cu. m., or for the whole, 10,738,260 francs (say $2,033,000). In addition to that, the coke ovens may be rebuilt in such a manner as to permit burning in them the comparatively poor blast furnace gases (e.g., during the time when the demand for power is insufficient to take care of the entire output of blast furnace gases). To an input of 5 cu. m. of blast furnace gas corresponds an output of 1 cu. m. of coke oven gas, and as there are about a quarter million of cu. m. of blast furnace gas available per hour during the 3760 hours per year when the demand for power is low, and as a cu. m. of coke oven gas may be taken to be worth 0.03 franc ($0.006), the increased coke oven gas production means an additional source of profit of 28,026,600 francs ($5,320,000). The by-products of coke oven manufacture represent a further sum of 2.50 francs (0.48), the total gain from the utilization of blast furnace and coke oven gases on a production of only 4,480,000 tons per year being as follows:

	Millions of Fr.	Dollars
Motive power from blast furnace gases, 5000 hours per year, at fr. 0.04 per kw-hr.	56.3	10.697
Motive power from coke oven gas, same assumptions as above	20.8	3.952
Coke oven gas used for chemical manufactures or lighting (fr. 0.03 per cu. m.)	10.7	2.033
Extra coke oven gas produced by the use of blast furnace gas in time of low demand for power	28.0	5.320
By-products of coke manufacture	14.9	2.831
Total	130.7	23.833

Investigation Concerning Heat Engine Operation (*Enquête sur le fonctionnement des machines thermiques*, *La Technique moderne*, vol. 7, no. 11, p. 369, December 1, 1913. 6 pp., 9 figs. *d*). *La Technique Moderne*, an important French engineering paper, has determined to start an inquiry as to accidents and difficulties connected with the use of high thermal efficiency prime movers, such as engines and turbines working with highly superheated steam, "poor" gas engines and gas producers, liquid fuel engines, either of the explosion or the Diesel type. The following points will be investigated: (*a*) causes of wear and deterioration of turbine blades; (*b*) difficulties encountered in the application of high superheats in reciprocating steam engines; (*c*) causes of rupture of air pump beams and shafts in reciprocating air pumps; (*d*) causes of rupture of bolts in the connecting rod head of single acting gas engines and causes of ruptures in internal-combustion engines generally; (*e*) causes of explosions in the casing, pipes, etc., of internal-combustion engine plants, etc.

The leading idea of the investigation appears to be that many accidents and troubles remain unexplained, and factory owners often hesitate in adopting a new type of engine, notwithstanding the economy that might be obtained by making the change, through fear of installnig too complicated and delicate apparatus. This brief program of the inquiry is followed by an article by Professor Letombe, of a general character, on various types of heat engines.

New Projects and Experiments in the Gas Turbine Field (*Neuere Vorschläge und Versuche über Gasturbinen*, Schultz. *Der Motorwagen*, vol. 16, no. 33, p. 833, November 30, 1913. 5 pp., 8 figs. *dg*). A review of the compressors proposed within the last few years for use in connection with gas turbines, such as the Pittler blower, the Brown-Boveri blower (works by means of an oscillating mass of water acting as a piston, somewhat like the Humphrey pump), the Lehne compressor, the Armengaud-Lemale system, etc. As regards the materials to be used in gas turbine construction, the most serious problems arise in connection with the construction of turbine wheels and blades, which are subjected to high stresses at the same time as to high temperatures. This is similar to what the steam turbine engineer has to deal with, with the difference, however, that the gas turbine material must also stand the chemical action of some of the constituents of the gases, e.g., hydrogen sulphate and sulphurous acid. The tests of Jahn have shown that the alloy which stood very well the chemical action of these gases at 420 to 436 deg. cent. (788 to 816.8 deg. fahr.) consisted of approximately 52.5 per cent copper, 22 per cent cobalt and 25.5 per cent zinc, while the action of wet sulphurous acid was best resisted by an alloy of 52.2 per cent copper, 30.4 per cent cobalt and 17.4 per cent zinc.

Tests of a New Peat Suction Gas Installation (*Versuche mit einer neuen Torf-Sauggasinstallation*, H. *Glasers Annalen für Gewerbe und Bauwesen*, vol. 73, no. 875/11, p. 208, December 1, 1913. 2 pp., 7 figs. *de*). The tests were made with peat suction gas engines and generators of German manufacture, the engine driving a dynamo (90 kw. at 740 r.p.m.) supplying current for the various requirements of the factory where the tests were made. The power output varied within wide limits and suddenly, jumping from normal load to one third of it, then to 68 kw., from which it fell to no-load, only to change back to 68 kw. Notwithstanding all these changes, the composition of the gas did not vary to any very serious extent. As regards fuel consumption the following data are quoted. The power delivered by the dynamo as indicated by the wattmeter was, for a 6-hour run, 420.5 kw-hr., to which corresponded a fuel consumption of 929.1 kg. (2044 lb.) of imperfectly dried peat, or 2.21 kg. (4.86 lb.) per kw-hr. (repeated control tests have given less satisfactory results). The current consumption for the fan drive took 5.3 kw., or about 7.5 per cent of the total power developed. In installations of more permanent type the fan ought not to take more than 6 per cent, in which case the total fuel consumption would amount to (100 : 94). 2.21 kg. = 2.35 kg. = 5.17 lb. per kw-hr. The peat was rather poorly dried (59.28 per cent of moisture).

Thermal and Mechanical Methods of Shop Treatment of Metals. Case Hardening (*Traitments thermiques et mécaniques des métaux a l'atelier, Cementation*, F. Robin. *Revue de mécanique*, vol. 33, no. 5, p. 409, November 30, 1913. 50 pp., 24 figs. *gp*. The second part of the abstract will appear in a future issue.) Two kinds of case carburization may be distinguished: complete carburization of metals or core carburization; and case carburization or case hardening of metal parts which must support considerable penetration stresses and at the same time must preserve as much of their malleability as possible.

The author discusses the various theories of case carburization and comes to the conclusion that carburizing action must be ascribed practically exclusively to carboniferous gases, namely, to carbon monoxide. In this connection it becomes important to consider the value of gases given off by various kinds of carburizers in use, especially in view of the fact that an excessive evolution of such gases may cause explosions during carbonization. De Nolly and Veyret have studied this problem and recommend the following precautions: (*a*) To avoid animal and vegetable matter giving off too much gas at low temperatures. (*b*) To use with barium carbonate (30 to 50 per cent) only charcoal carbonized at a very high temperature. The evolution of gas is thus smaller and the percentage of hydrogen lower. (*c*) To heat the mass slowly up to 700 deg. cent. (1292 deg. fahr); the air can then escape and the violent evolution of gases at a temperature around 700 deg. cent. is reduced.

As regards possible weakness of the core of the carbonized part, nitrogen is only occasionally the cause, but hydrogen is far more dangerous in that it produces hard or brittle places consisting of pure ferrite.

The evolution of gases with different kinds of carburizers in use occurs approximately in the following manner: Pure charcoal at temperatures from 0 to 300 deg. cent. (32 to 572 deg. fahr.) evolves gases which are absorbed by the charcoal itself. At 300 deg. cent. (572 deg. fahr.) there is a minimum of gas generation. The air is driven off and the volatile gases are still occluded. From 300 deg. to 700 deg. cent. (572 to 1292 deg. fahr.) the internal evolution of the gases takes place, and at 700 deg. cent. there is a maximum of evolution equal to about 30 times the volume of the charcoal. Beyond that temperature the evolution of the gases decreases. At 1100 deg. cent. (2012 deg. fahr.) the contents of carbon monoxide increases a little. At the second heating the evolution of gas is very weak. The mixture of barium carbonate and charcoal calcined at 1000 deg. cent. (1832 deg. fahr.) gives off practically no gases until 600 deg. cent. (1112 deg. fahr.), the evolution of the gases reaching its maximum toward 1000 deg. cent. At 1050 deg. cent. (1922 deg. fahr.) the gas contains 75 per cent carbon monoxide and 12 per cent hydrogen. Ferro-cyanide carburizers reach their maximum of evolution of gas at about 800 deg. cent. (1472 deg. fahr.), but very rapidly cease to give off gas.

Case carbonization is therefore the result of the absorbtion by iron of the carbon left in the carburizing material by the evolution of the gases, but in order that iron might absorb carbon, it must be in the allotropic state γ, since iron in the state α does not dissolve carbon, at least not constantly and in a useful manner. By heating iron in close contact with the carburizer above 700 deg. cent. (1292 deg. fahr.), or even up to 560 deg. cent. (1040 deg. fahr.) the beginning of carburization is obtained. Giolitti and Carnevali have shown that steel with very low content of carbon is not carburized at all below 780 deg. cent. (1436 deg. fahr.), and they explain facts to the contrary mentioned above by supposing that carbon monoxide easily penetrates into iron at the temperature around 500 deg. cent. (932 deg. fahr.) and by decomposition deposits there carbon which is not really dissolved in the iron. Charpy appears, however, to have produced under these conditions superficial cementite which tends to show a certain solubility of carbon. However, industrial case carbonization of iron does not begin until about 850 deg. cent. (1562 deg. fahr.). Steel subjected to case carbonization often has an initial content of carbon of 0.3 per cent, not counting manganese, silicon and other elements. The point of transformation in such cases easily reaches 780 deg. cent. (1436 deg. fahr.), and the carburization once started, the piece of steel is rapidly covered by a thin layer of iron more or less saturated with carbon of which the normal temperature of transformation is only 700 deg. cent. (1292 deg. fahr.). Between this external layer and the core of the metal piece there are formed other layers of a transitional nature with regard to the point of transformation which gradually rises as the layer is deeper inwards. The diffusion of these layers from one to the other occurs the more rapidly the higher is the temperature used, but is very slow and more often ceases altogether at a certain point if the temperature is below the temperature of transformation in that region, hence the too sudden transition in the composition of the piece which may be harmful to the strength of the case carbonized layer. The pieces when case carbonized ought, therefore, to be heated at least up to 850 deg. cent. (1562 deg. fahr.). For the investigation of the results of the case carbonizing operation two methods may be used—chemical analysis and microscopic investigation.

For the chemical analysis, very thin shavings from the surface of the metal might be taken by a milling machine and analyzed, thus showing the distribution of the carbon throughout the depth of the piece. This process is very useful in scientific investigations, but cannot be conveniently applied in the shop where microscopic investigations are preferable. The microscope shows the thickness of the carburized layer with its variations in the content of carbon and the physical structure of the core, the transitionary layers and the periphery on which depends the cohesion of the various regions and the brittleness of the whole piece, but the microscope does not indicate the sulphur contents and the presence of occluded gases—factors of great importance for determining the quality of the final product.

The author shows by figures how various iron-carbon compounds look under the microscope.

Thickness of carbonization should be not more than one-third of the depth of the piece carbonized, since otherwise rupture through excessive brittleness of the periphery may be produced. If the piece is case hardened only on one side, however, it is said that the carbonization may go as far as one-half of the depth. In cases where the carbonized piece is subject to shocks, it is necessary that the depth should be less than when it is subject only to static stresses.

As regards the selection of carbonizing materials, the following general conditions may be stated: (*a*) The carburizer ought to have as high a velocity of carburization as possible, since the longer the operation lasts the more expensive it is and the more chance there is for the metal to change its properties. It is also better to work at as low a temperature as possible. (*b*) The carburizer must not contain sulphurous matter, as the metal absorbs it and becomes hot short. At most there may be up to 2 per cent of sulphur at a temperature between 900 and 950 deg. cent. (1652 to 1742 deg. fahr.). At between 950 and 1000 deg. cent. (1742 and 1832 deg. fahr.) the sulphur volatilizes. At the surface 0.88 per cent of sulphur has been found. (*c*) The carburizer must be as good a conductor of heat as possible. This is important in order to minimize the errors

due to the difference of temperature of the furnace and the pieces carbonized, each of the latter being heated in the powder in order to avoid the inconvenience of too long cooling. (*d*) It must have as low specific heat as possible. This property is necessary for the same reason as the preceding one. It is always well to heat up the box as quickly as possible, in order to avoid substantial errors with respect to the time of heating and its temperature, as well as to eliminate useless heating losses. (*e*) The carburizer must not alter the surface of the piece. Scratches, erosions, etc., require expensive machining and are harmful to pieces where precise dimensions have to be maintained. (*f*) Where brittleness must be avoided at all costs, it is necessary to adopt other conditions, often less compatible with the preceding ones, namely: (*a*) *Progressive* penetration of the carbon into the iron; a carburizer which acts too suddenly and roughly produces often hypereutectoid layers. When precision in the operation is required with the formation of the thin but hard layer, the composition and action of the carburizer have to be very exact. (*b*) In addition to that, a good carburizing powder has to satisfy the following conditions: (*a*) it must contain materials which can be easily powdered in order to give a uniform and close mixture; (*b*) it must not exhaust rapidly; good case carburizers can be used many times with great economy and regularity of results. (*c*) It must *not* be expensive; must be free of danger of explosions; and must not produce dust excessive in quantity or dangerous in action. (*d*) It must not decrease in volume while in the carburizing boxes, since the heaping up of the carburizer would become unequal and some pieces undergoing case hardening might be left bare. Hence the necessity to avoid too fluid or volatile elements in the composition adopted.

The author discusses in detail the use of various carburizers—solid, liquid and gaseous. Among solid carburizers the best known are mixtures of carbon and salts, the carbon used being for the most part charcoal powder, the best being poplar charcoal which gives charcoal practically free from sulphurous matter. A mixture very widely used is that of charcoal and barium carbonate, the proportions generally adopted being 60 per cent of carbon and 40 per cent of barium carbonate. This mixture acts mainly through the evolution of carbon monoxide. Whether the presence of nitrogen is absolutely necessary for the carburization or not has not been fully established. Barium carbonate is selected for its high temperature of dissociation. Calcium carbonate substituted instead of it gives an evolution of gas at considerably lower temperature, but the proportion of anhydride carbonate is much larger, which is not favorable to good carbonization.

The author shows by a diagram the depth of penetration with the mixture of charcoal and barium carbonate for various temperatures and lengths of carbonization, prepared in accordance with the experiments of L. Guillet.

With a mixture of charcoal, barium carbonate and ferro-cyanide, the admission of potassium ferro-cyanide appears to heighten the activity of the carburization process and to increase the hypereutectoid layer at the temperatures of industrial case hardening. An interesting point to remember is that powder which has been used several times is still very good and often even better the second time than it was the first time, probably owing to the loss of moisture; no iron is found in the state of free ferro-cyanide when the heating took place at the high temperature.

Mixtures of other salts have been tried with charcoal, giving practically analogous results to the use of the mixture of charcoal and barium carbonate, but the carbonizing power of the material used would become exhausted much more rapidly. A mixture of charcoal and sodium chloride (10 per cent of the latter) gives a good carbonizer and possesses regenerative power, is very cheap and can be used for case hardening to a depth of 1 mm. (or .04 in.). It is, however, too long to heat. A French investigator, Grenet, mentions the following carburizers for use in shops. They are arranged in the order of speed of carburization and price:

(*a*) A mixture of sawdust with forge coal containing 30 per cent of volatile matter. (*b*) A mixture of pulverized charcoal, 1 kg. with 1½ kg. of sawdust and 0.1 kg. of sodium chloride. (*c*) A mixture of 0.5 kg. forge coal containing 30 per cent of volatile matter, 0.5 kg. of carbonized leather, 0.1 kg. of sea-salt and 0.5 kg. of sawdust. (*d*) A mixture of 1 kg. of carbonized leather, 1 kg. of sawdust and 0.2 kg. of ferro-cyanide. According to the patents of Lamargese, charcoal from certain definite woods, and especially from resinous woods, alone or with an addition of silicon, gives excessive hardness. Coke impregnated by residues from petroleum distillation is an active carburizing material, but it is of irregular composition, which causes different results in different operations. A mixture of charcoal and concentrated solution of potassium-cyanide or charcoal and ferro-cyanide has been patented as a means of obtaining rapid case hardening admitting good practical control of results. It appears also that the view that the addition of cyanide of nickel or potassium bichromate to the carburizing material produces penetration of nickel or chrome into iron, is incorrect.

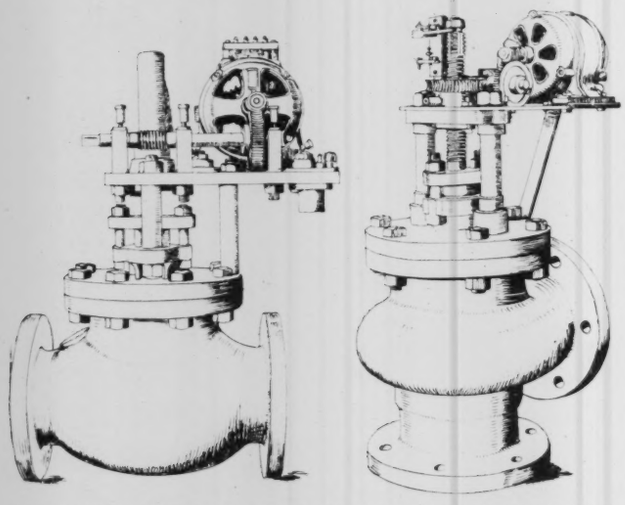
In all the experiments which the author has made at the high temperature around 1000 deg. cent. (1832 deg. fahr.), the most intense case carburization appears to have been produced by a mixture of charcoal with 40 per cent of barium carbonate. The most violent carbonization with the largest hypereutectoid layer at all has been obtained by the use of carbon alone. There may be an infinite number of formulas by the use of which good results may be obtained as long as these formulas do not depart from the general rule: carbon, or products evolving carbon, added to little volatile salts, preferably carbonates or cyanides, which act as generators of gases with the carbon base, these salts being in a powder in a quantity equal to that of the carbon. The author only cautions against the use of toxic products or products giving off poisonous gases, as well as nitrogenous products which in mixture with the carbon may produce explosions. Saltpeter in particular must be used only with the greatest care, since otherwise a mixture approaching the composition of black powder may be produced. A mixture of 60 per cent of saltpeter, 29 per cent of prussiate and 9 per cent of colophonium gives also a rapidly acting explosive.

A New Optical Pyrometer: The Radium Pyrometer, and a Gas Heated, Absolutely Black Body (*Ein neues optisches Pyrometer: das Radium-Pyrometer, und ein mit Gas beheizter, absolut schwarzer Körper*, W. Allner. *Journal für Gasbeleuchtung*, vol. 56, no. 47, p. 1145. 5 pp., 7 figs. *d*). A brief discussion of the theory of optical pyrometers followed by a description of a new type invented by the author. The radium pyrometer uses for the light stand-

ard not an electric light, but a special radio-active product, and the measurement is made not in the red line of the hydrogen, $\lambda = 0.6563\mu$, but in the green radium line of $\lambda = 0.535\mu$. The radium pyrometer is not as accurate as either the Wanner or the Holborn and Kurlbaum pyrometers, since the radium light decreases at the rate of approximately 1.4 per cent per month, or 20 per cent per year.

Steam Engineering

Electrically Operated Valves and Their Application (*Elektrisch angetriebene Ventile und ihre Verwendung*, E. Claassen. *Zeitschrift des Vereines deutscher Ingenieure*, vol. 57, no. 49, p. 1946, December 6, 1913. 5 pp., 15 figs. *d*). The gate valve has a great advantage over the slide valve in that it is materially cheaper to build and therefore in small and middle sized plants it will probably be used for a long time to come. It becomes therefore of importance to provide means for its improvement, and especially for ways to close and open at a distance. One of the most convenient methods of doing it is by electric operating attachment. One of the devices for electrically operating large valves is shown in Fig. 10, providing both for an electric



Figs. 9 and 10 Combination Hand and Electrically Operated Valve

and hand operation. The motor is so installed that it does not take much space. The high speed of rotation of the motor is reduced by means of a worm drive, and at the highest and lowest positions of the valve cone the current is automatically cut out. These valves can be connected with manometers and special switching devices; for example, if in the low pressure piping a contact manometer is included and set at 6 atmospheres, contacts are provided for 6.1, 6.05, 6, 5.95 and 5.9 atmospheres. If the pressure goes down from 6.1 to 6 atmospheres, the valve by the action of the current is opened one-quarter of its stroke and is closed automatically again when the pressure rises to 6.1 atmospheres. When too much steam is drawn off and the valve must be opened still more, it will open one-half stroke at a steam pressure of 5.95 atmospheres and will open fully at 5.9 atmospheres.

In the same manner as the pressure reducing device, the electrically operating valve may be used also as a safety valve in case of the rupture of the pipe, Fig. 11. Here also a contact manometer is used. As soon as the pressure in the pipe falls off owing to the rupture of the pipe, the indicator of the manometer closes the current. The valve is immediately closed and remains closed until the pressure in the piping rises to its initial value.

In large water pipe systems a float device with contacts may be used in a similar manner instead of a manometer either with or without an alarm device. The electrically operated valve may be also applied where a mixture of hot and cold water has to be maintained at a certain temperature. In this case a receiver thermometer, Fig. 12, is in-

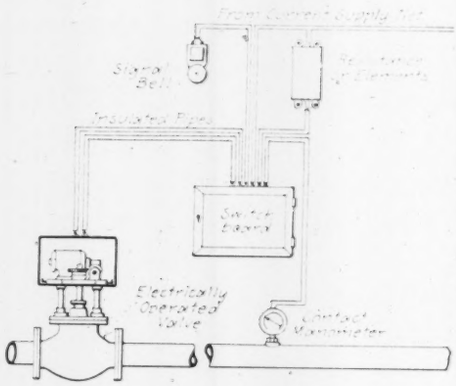


Fig. 11 Valve with Signalling Attachment and Electrically Operated Device for Automatically Closing in Case of Rupture of Pipe (for Steam and Gas Piping)

stalled with a number of contacts to which correspond a similar number of contacts on the switchboard, the thermometer closing and opening the current at the contacts and thus producing respective variations in the position of the valve.

In the same manner may be regulated the temperatures of steam and water heating systems or ventilator systems. One of the peculiarities of this system is that it can be used only with high tension current. This makes no difficulty in water pipe systems where electric power is generally used all the time, but in small steam plants its dependence on high tension current is a disadvantage. Where high tension current is not available, valves operated by electromotors at a distance cannot be used. The problem of operating valves at a distance in such cases has been solved in various places in different ways.

Thus in Moscow, where electric current is not always available for the use of the water supply system, special arrangements had to be made to close the water supply in houses in districts where a fire occurred, since otherwise the pressure available would not be sufficient for the operation of the fire engines. This was done by means of the Simin valve, Fig. 13. In case of a fire, the water supply station sends a pressure surge into the piping, and by this means all the valves in the private houses are closed.

In the Singer Sewing Machine Company's plant at Podolsk in Russia, an electrically operated valve is used, but instead of an electro-motor the lever of the valve is operated by a system of electro-magnets, Fig. 14. The magnets, *a*, are excited by wet batteries, which may be switched in at any place desired, the magnets then attracting a common armature, *b*, which liberates the tip *c* of an intermediate piece. The lever of the pipe isolating valve presses against *d*, and

by its own weight as well as by the water pressure against the pipe isolating valve *d*, is turned outwards, but as soon as the lever of the pipe isolating valve falls down, the spring *c* draws *d* back into its old position.

An improved type of the same kind of valve manufactured by a German concern is also described in detail.

TECHNICAL AND ECONOMIC EXPERIENCES IN STEAM TURBINE OPERATION (*Technische und wirtschaftliche Erfahrungen im Dampfturbinenbetrieb*, Professor Josse and K. Hoefer. *Zeitschrift für das gesamte Turbinenwesen*, vol.

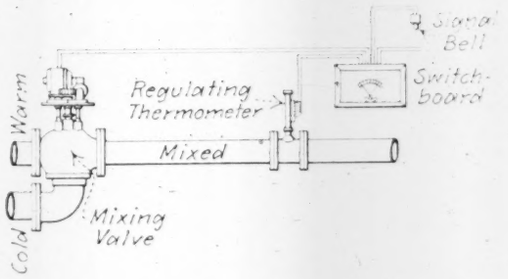


FIG. 12 ELECTRICALLY OPERATED MIXING VALVE

10, no. 33 and following, serial article, not finished. S.A. An abstract of the rest of the article will appear in an early issue). At the end of 1912 Professor Josse sent out a circular letter to a large number of electric power plants equipped with steam turbines for the purpose of obtaining a general view of the experiences gained during the last few years in steam turbine operation from a technical and economic point of view. About 130 such letters were sent out, and approximately 50 per cent answered, which gives a fairly good view of the situation as it is in Germany. The data of this investigation were worked out later on by K. Hoefer.

All the turbines have been divided into two main classes: average size, from 250 to 1000 kw., and large turbines with the useful output in excess of 1000 kw. Further, a distinction has been made between the following five classes: (*a*) pure reaction turbines; (*b*) reaction turbines with a high pressure impulse wheel such as the Curtis wheel; (*c*) pure impulse turbines such as the Zoelly; (*d*) impulse turbines with a high pressure Curtis wheel; and (*e*) impulse turbines with Curtis wheels only.

This investigation shows that for turbines of average output the pure Curtis system prevails, while the reaction turbine is mainly used in large sizes. The selection of the turbine type is, of course, governed not only by technical, but also by commercial considerations; but it must be borne in mind that the introduction of the impulse and Curtis types have begun later. Still it appears that the reaction system is more adaptable to large than to small sizes.

The investigation has confirmed the fact which has been generally known before, namely, that the sizes of turbines have a tendency towards rapid increase. The difference in the rate of increase for various types of turbines cannot, however, be established. As regards the introduction of turbines, there was a noticeable falling off in the year 1910, due probably to the economic disturbances of 1908; but in the last two or three years there was again a rapid move upwards. In 1912 only there have been installed new turbines with a total capacity of approximately 115,000 kw. and average power of 4250 kw. per unit.

The speed of rotation in the case of drum turbines and polyphase generators is usually 3000 r.p.m. for outputs of 1000 kw.; for larger outputs up to about 4000 kw. the speed is usually about 1500 r.p.m., and goes down to 880 r.p.m. for a still higher output. In disc turbines driving polyphase generators this speed varies from 3000 r.p.m. for outputs up to 2000 kw. to about 1500 r.p.m. in the case of larger outputs. With turbines driving direct-current generators, which is done only in the case of smaller units, the speed used is usually lower, owing to commutation troubles at higher speeds. The turbines work without exception with superheated steam at about 300 deg. cent. (572 deg. fahr.) and pressures up to 12 atmospheres gage

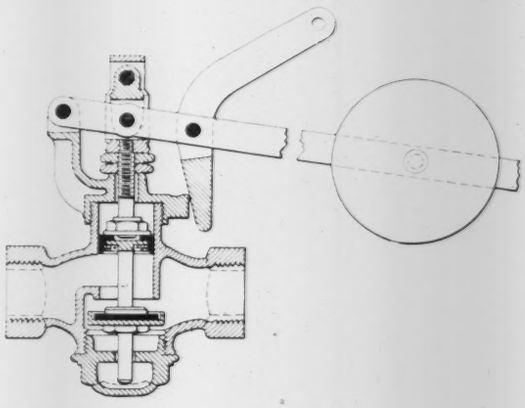


FIG. 13 SIMIN VALVE FOR TOWN FIRE SYSTEM, OPERATED BY A PRESSURE SURGE FROM THE MAIN SOURCE

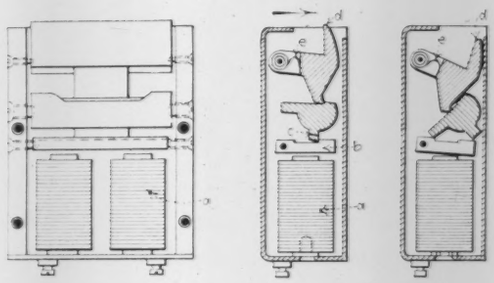


FIG. 14 VALVE OPERATED BY ELECTROMAGNETS

with condensation. The number of stages in the case of reaction turbines is indicated in Table 5.

TABLE 5 NUMBER OF STAGES IN REACTION TURBINES (GERMAN PRACTICE)

Output, kw.	1500	2000
Steam pressure, atmospheres gage	12	12
Temperature, deg. cent./fahr.	300/572	300/572
Vacuum, per cent	97	95
Speed, r.p.m.	1500	1500
Number of pressure stages	two-rim impulse wheel and 50 stages	no impulse wheel, 71 stages

The new types of reaction turbines and impulse turbines of the Zoelly type are provided nearly always with one high

pressure impulse wheel which is usually made with two and sometimes three velocity stages. It was found that during 1912 the Zoelly impulse turbines have been built with smaller numbers of stages. When lower speeds are used, the number of stages is generally larger than with higher speeds, which is of course required in order to obtain good peripheral velocities with a diameter of wheel which is not excessive. The pure Curtis turbines are built mostly with two pressure stages and two velocity stages per pressure stage, and only seldom with more pressure stages.

Governing. A universal effort has been observed to make governing as sensitive as possible. All the concerns building turbines are passing from pure throttling governing to a combined system of governing or nozzle governing, which is more economic at partial loads. Nevertheless in the largest number of turbines, especially small turbines, now in operation throttling governing is used, which is due to the fact that combined governing in the case of reaction and Zoelly turbines has become possible only through the introduction of the high pressure Curtis wheel. In the majority of cases the governing is operated by means of a servomotor which usually works with oil under pressure. The latter system is replacing former designs where steam was used as motive power. The sealing of stuffing boxes is done nearly exclusively by steam, and cases where oil or water is used as sealing liquid are comparatively rare. The use of oil is undesirable on account of the possibility of the oil penetrating into the water of condensation, which would destroy the advantage which steam turbines have with respect to reciprocating engines. The regulation of the steam sealing pressure is done nearly always by hand, and automatic devices for this purpose are provided in only rare cases.

The safety of the operation of steam turbines is generally considered very high, but it is claimed that a steam turbine requires the same care in attendance as reciprocating engines. It is also noticed that the cause of breakage of steam blades can be in only rare cases established with certainty. It is sometimes ascribed to imperfect installation, at other times to non-uniform cooling of the rotor, while in many cases poor material has been probably the cause. It is also very likely that the properties of material are so affected by continuous work at high temperatures that the material cannot withstand the stresses which occur in it. Besides the blading, the layers of the cams and the servomotor require the most attention.

Generators. In the case of direct current generators the voltage seldom exceeds 500 volts. In polyphase and two-phase generators the voltage varies usually between 2000 and 3000 volts, and is often as high as 6000 volts. For still higher tensions 10,000 volts is usually selected. Direct current is found only in small plants. Noise produced by the generator sometimes exceeds permissible limits. It has been observed that it may be reduced by passing the cooling air, not into the machine room, but direct into the atmosphere through a special passage. The air heats up in the generator usually to 40 or 50 deg. cent. (104 to 122 deg. fahr.), while temperatures up to 60 deg. cent. (140 deg. fahr.) are still permissible. Sometimes water cooling is provided. In nearly one-half of the generators the cold air is filtrated, which is done in order to prevent short circuiting by the deposits of dust; especially in turbogenerators, which have been installed lately, is such a device provided.

Condenser Plants. The prevailing type is the single surface condenser. Jet condensers are installed usually with turbines of small output, but sometimes also in large turbines up to 7000 kw. A central condenser has been found only in one plant, while in several cases jet condensers have been provided as a reserve to an existing surface-condenser system. In single condenser installations the pressure fall is so small that it can be determined only by a very exact measurement. In several cases a pressure of only 0.5 per cent had been observed, while the highest fall of pressure indicated is only 1.7 per cent. As regards the vacuum, the requirements are increasing all the time. In modern power plants a vacuum of 93 or 97 per cent is found, while even as high as 98 per cent is given as existing in a number of plants. The correctness of such data as 97 or 98 per cent is very often doubtful since, as Professor Josse has previously shown, it is very difficult to measure correctly high vacua; and it appears that in several cases where the control test of the vacuum can be made by measuring the temperature of the warm water of condensation, this temperature was higher than the saturation temperature corresponding to the given vacuum, and the difference was much larger than would be ascribed to errors of observation (from 10 to as much as 30 deg. cent. (18 to 54 deg. fahr.). It is therefore reasonable to suppose that in the most cases the high vacua from 94 to 98 per cent were not actually available.

It did not prove possible to express by means of curves the relation between load on the condenser and vacuum. With the vacuum of 93 to 97 per cent, the amount of cooling water equal to about 60 times that of water of condensation, and the cooling temperature of 15 to 20 deg. cent. (59 to 68 deg. fahr.), on the average, a load of 22 to 23 kg/qm. (4.43 to 4.63 lb. per sq. ft.) per hour has to be taken. The amount of cooling water per kg. of steam varies between 40 and 80 kg., the lower value being of course for colder cooling water and vice versa; on the average about 60 times the weight of cooling water is used.

For the packing of condenser pipes the use of stuffing boxes appears to be preferred, nearly two-thirds of all condensers being equipped with them. In other condensers the pipes are rolled in, the different types of packing being equally used both in small and large condenser units. The use of rubber rings is rare, unless stuffing boxes are also used. Sometimes the pipes are rolled in on one end and provided with stuffing boxes on the other, which permits the pipe to move freely.

As regards the types of pumps in connection with condensers the wet pump and the centrifugal pump for cooling water still predominate, owing to their simplicity and low cost. The wet pump is mainly driven by an eccentric from the main turbine. When the suction of the water of condensation and air are done separately, the centrifugal pump is mainly used. The suction of air by means of jet devices is still rare, owing probably to the fact that this kind of apparatus in a simple form has been introduced only recently.

It is worth while to notice that the power consumption of separately driven pumps is higher than when the pumps are driven from a common source, which may be ascribed to the fact that the losses in a number of small motors are generally larger than when one large source of power is used. The driving of the pumps by means of the steam turbine appears to involve a larger power consumption than

by means of an electric motor, probably due to the larger speed of rotation when a steam turbine is used.

The exhaust steam of the auxiliary turbine is nearly always used for the low pressure part of the main turbine. Direct feeding of boilers by means of a condenser pump taking water by suction from the condenser is met with only seldom, although this system admits the simplest automatic regulation of the water level in the boiler, and reduces the heat losses to a minimum. The additional water used for feeding the boiler is as a rule previously passed through a water cleaning device. Since the presence of oil in water of condensation of steam turbines is not expected, in no case is an oil separator device used, but it must not be forgotten that a certain amount of impurities may be introduced by the action of the condenser pumps, which may, however, happen only where wet pumps are used in the condenser plant, or where a separate suction of air and water of condensation is used, and the latter is handled by reciprocating pumps which use oil for lubricating their stuffing boxes. In more modern types of condenser plants the water of condensation is taken care of nearly exclusively by centrifugal pumps, so that all pollution by oil is eliminated.

Disturbances in the action of condenser plants are extremely rare, and when they occur they are mostly due to poor material or imperfection in handling the plant. The valves of the pumps must of course be inspected from time to time, as excessive wear may be a source of trouble, and in the case of air pumps may affect the vacuum.

Locomotive Cinders as a Fuel for Steam Boiler Furnaces (*Rauchkammerlösche als Brennstoff für Dampfkessel*, O. Nerger. *Zeitschrift des Vereines deutscher Ingenieure*, vol. 57, no. 52, p. 2067, December 27, 1913. 4 pp., 5 figs. *de*). There were numerous attempts to utilize for fuel purposes locomotive smoke box cinders which contain from 3500 to 4500 WE. (6300 to 8100 B.t.u. per lb.). But all such attempts have generally proved unsuccessful, owing to the difficulty of burning the cinders on any kind of grate, the grain of the cinders being very uneven, and varying from fine dust to pieces up to 5 mm. (or 0.2 in.). Several experiments have been made on burning such cinders together with coal rich in gaseous compounds on undergrate blast furnaces, such as the Kudliez or Kridlo types, but these furnaces require that the charging, shifting of the fire and removal of clinkers be made by hand; so that frequent opening of the fire doors allows the entrance of cold air with its attending heat loss, and at the same time makes it difficult to maintain an even fire. Even at that, the cinders did not burn well and a large proportion of them were carried over into the ashes or sent out through the flue.

The tremendous amount of locomotive cinders obtained every year led the German engineers to experiment actively in order to find a system by which this kind of fuel could be burned *without* an admixture of coal rich in gaseous compounds. Attempts have been made to use special forms of arches, chain grates, inclined-step grates, and so on, but up to this time no attempts were successful in burning more than 40 per cent of the cinders in a mixture of high gas coals. It was only lately that the State Railway Administration Division of Breslau, in installing a large roundhouse at Oels, again made a series of experiments on the utilization of locomotive cinders for boilers with what appears to be fair success. They use a modified type of forced draft furnace with traveling grate of the Pluto stoker type. With the ordinary type of the Pluto stoker, the operation was not quite successful, as notwithstanding the motion of the hollow grate elements, the cinders have exhibited a tendency to bake together and in this way to interfere with the traveling of the fuel over the grate, which very unfavorably affected the steam output of the boiler. Further, the baking of the cinders prevented the air from reaching the fuel, resulting in incomplete combustion and the passage of a considerable amount of the cinders into the ashes.

The main advantages were secured by the introduction of steam into the hollow grate elements. After this was done, the slags remained fluid and did not form clinkers on the grate elements, the travel of the fuel over the grate became better and greater combustion velocities became possible. Further, the action of steam helped to obtain far more powerful combustion than was possible in the early experiments, the ashes were well burned out and contained only little combustible material. The other modifications were of a secondary nature and referred to regulation of velocity, distance of motion of the hollow grate elements, air pressure of the grate, etc.

These experiments have shown that with the modified Pluto stoker, it is fully possible to obtain a comparatively good efficiency of combustion with locomotive cinders. The main element of success in this test was a continuous breaking up of the fuel by the relative motion of the hollow grate elements which gave the air of combustion means of access to the fuel. The high combustion temperature required in this case has been made possible with the Pluto stoker by the use of a special fire return arch, Fig. 15. As shown, the brick work is arranged in a manner such that over the upper part of the grate there is only quite a short arch, the only purpose of which is to protect the header and the pipe connections against the action of the hot gases. On the other hand, there is a long arch over the entire lower part of the grate, fairly close to the grate. The flames, therefore, go not as in other systems of firing from the front backwards, but from the back forward, and a large amount of radiation is obtained, directed towards those parts of the fuel which have just reached the grate, so that the fuel has an opportunity to reach the temperature of ignition in the early zones of the stoker. With the gradual travel over its path of combustion, the fuel has plenty of time fully to burn out.

The main data of the tests are given in Table 6, which shows that with this system of firing comparatively great efficiency is obtained with cinders as fuel, the steam output is comparatively high and would probably be still higher if the tests had not been made with a boiler of somewhat antiquated design. The evaporation with respect to the fuel used is fairly good. The contents of carbon dioxide were as high as 9 per cent, which shows that quite a favorable excess of air had been secured. The flue gas temperature was comparatively high, which depended probably on the construction of the boiler, and the loss from this source could be considerably reduced by a better design. The slags and the ashes were well burned out and contained only traces of combustible material. The amount of ashes taken out by the flue was insignificant and contained little combustible material.

The author gives a cost calculation for three cases, using German cost data, and shows thereby that the use of loco-

motive cinders on a modified Pluto stoker gives a considerable economy over a chain grate on which are burned locomotive cinders together with ordinary coal.

Evaporation Tests of L. Weiss and the Law of Evaporation for Stationary Boilers (*Verdampfungsversuche von L. Weiss und das Verdampfungsgesetz für ortfeste Dampfkessel*, O. Köchy. *Zeitschrift des Vereines deutscher Ingenieure*, vol. 57, no. 52, p. 2070, December 27, 1913. 4 pp., 5 figs. *etA*). The tests described were made with the boilers shown in Fig. 16, made possible by the fact that each of the boilers was divided into two parts with independent water feeds. The heating surfaces of the boilers were as follows:

	Qm.	Sq. Ft.
Fire tube with lower drum bottom	29.59	320.49
Upper drum with water tubes	132.36	1424.70
Upper drum shell	16.04	172.65
Lower drum shell	22.61	243.35
Superheater	50.00	538.19
Grate area	3.68	39.60

The results of tests are given in Tables 7 and 8.

On the basis of these tests, and the author's previous in-

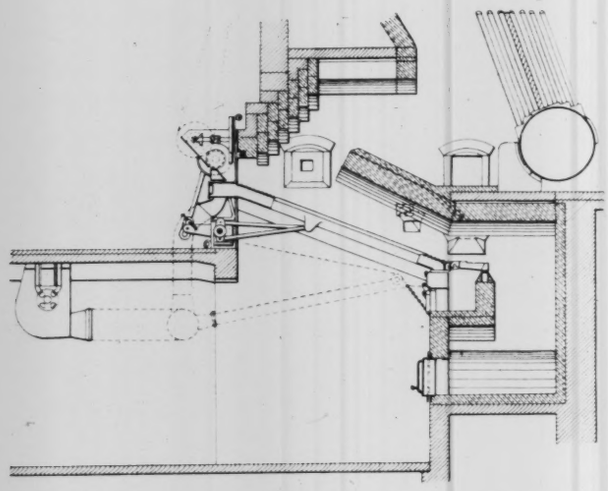


Fig. 15 Furnace of the Modified Pluto Stoker Type for Burning Locomotive Smoke Box Cinders

vestigation on The Law of Evaporation and The Law of Heat Transmission in Locomotive Boilers (*Zeitschrift des Vereines deutscher Ingenieure*, 1912, p. 520), the author established an equation which, in general terms, he expresses as follows:

$$\theta_n = \frac{a}{b + \frac{H_n}{R}}$$

where H_n is a section of the heating surface of a boiler, in square meters, measured from the grate up to a certain point n on that surface; R is the grate area in qm. θ_n is the amount of steam generated per square meter of H_n per hour, in kilograms, while a and b are constants. These constants can be determined in the following manner: from Table 7 the evaporation per hour from the two lower drums with their shells was $\frac{17080 + 18970}{11} = 3280$ kg., and from the two upper drums and their shells: $\frac{7480 + 8700}{11} = 1470$ kg., and from all four together: 4750 kg. With a superheat $\frac{105 + 106}{2} = 105.5$ deg. cent., specific heat of superheated steam 0.552, and heat of evaporation $\lambda = 662 - 21 = 641$, the output of the superheater, in wet steam units, per hour, is $\frac{4750 \times 0.552 \times 105.5}{641} = 430$ kg., which brings the total output of the two boilers up to 5180 kg. Further let $H_2 = 2 \times 29.59 = 59.2$ qm., the heating surface of the two lower drums H_3 the heating surface from the grate to the end of the superheater, assuming that the latter, insofar as it participates in the transmission of heat, is

TABLE 6 TEST OF FIRING LOCOMOTIVE SMOKE BOX CINDERS

Date of test	June 20, 1913
Type of Boiler	Water tube
Heating surface	125 qm. (1345 sq. ft.)
Firing system	Pluto stoker, 5.91 qm. (53.60 sq. ft.) grate area
Length of test	3 hours
Fuel	
Kind and size	Unscreened locomotive cinders, up to 0.4 mm. (0.015 in.) grain
Heating value	4061 WE (7309 B.t.u. per lb.)
Consumption: total	1690 kg. (3718 lb.)
per hour	562 kg. (1236 lb.)
per hour per qm. grate area	95 kg. (19 lb. per sq. ft. grate area per hour)
Feedwater	
Total evaporation	6330 kg. (13926 lb.)
Evaporation per hour per 1 qm. heating surface	16.8 kg. (3.45 lb. per sq. ft. heating surface per hour)
Evaporation per hour per 1 qm. heating surface in terms of steam at 100 deg. cent. (212 deg. fahr.) and water at 0 deg. cent. (32 deg. fahr.)	17.7 kg. (3.64 lb. per sq. ft. heating surface per hour)
Temperature of feedwater	42 deg. cent. (107.6 deg. fahr.)
Steam	
Pressure, gage	10.2 atmospheres
Temperature	275 deg. cent. (527 deg. fahr.)
Total heat	718 WE (1292.4 B.t.u.)
Heat produced in the boiler	676 WE (1216.8 B.t.u.)
Flue Gases	
Temperature at the boiler end	310 deg. cent. (590 deg. fahr.)
CO_2 content at the boiler end	9 per cent
CO content	0 per cent
O_2 content	9.5 per cent
Pressure in the hollow grate elements	12 mm. (0.5 in.) of water
Temperature of the air	20 deg. cent. (68 deg. fahr.)
Heat Balance	
Useful output of boiler and superheater	2590 WE 4662 B.t.u.—63.5 per cent
Losses in the flue gas (free heat)	829 WE 1492 B.t.u.—20.4 per cent
Losses through radiation, incomplete combustion, etc.	642 WE 1155.6 B.t.u.—16.1 per cent
	4061 WE 7309 B.t.u.—100 per cent

replaced by an ideal wet steam heating surface. The exact value of H_2 is therefore as yet unknown.

$H_3 = H_2 + 2 \times 132.36 = H_2 + 265$ qm., the heating surface up to the end of the nest of boiler tubes.

$H_4 = H_2 + 265 + 2(16.04 + 22.61) = H_2 + 342$ qm., the total heating area of boilers, including the shells.

The values of these heating surfaces, with the values of the respective evaporations are tabulated in Table 9. The values of evaporation for H_1 to H_3 are somewhat inexact because they include the evaporation due to the shells, which properly belongs only to H_4, but the amount of evaporation from this source is quite insignificant.

For a first approximate calculation of the constants a and b the heating surface of the superheater is neglected, and H_2 made equal to $H_1 = 59.2$; hence $H_4 = 59.2 + 342 = 401.2$ qm., and from this it follows that the average evaporation per square meter is for

TABLE 7 L. WEISS TESTS OF EVAPORATION IN A SCHWOERER BOILER

Boiler No.	2919		2920	
Steam temperature, deg. cent.-fahr.	288	550.4	289	552.2
Superheat, deg. cent.-fahr.	105	189	106	190.8
Temperature of feedwater, deg. cent.-fahr.	21.2	70.2	21.3	70.4
Coal consumption, kg.-lb.	3001	6602	3350	7370
Evaporation in lower drum, kg.-lb.	17080	37576	18970	41734
Evaporation in upper drum, kg.-lb.	7480	16456	8700	19140
Heating value of coal, WE-B.t.u.	7428	13370	7428	13370
CO_2 content in flue gases, per cent	12	12	12	12

TABLE 8 AVERAGE TEMPERATURE OF FLUE GASES

(Measured at Points indicated in Fig. 16)

	Deg. Cent.	Deg. Fahr.
At exit from fire tube	872	1601.6
At entrance to upper drum	720	1328.0
At exit from upper drum	342	647.6
Flue gases at damper	243	469.4
Average gas temperature, superheater	470	878.0

TABLE 9 PARTIAL HEATING SURFACES OF THE BOILER UNDER TEST, AND THEIR RESPECTIVE EVAPORATIONS

Heating Surface H_n in qm.		Evaporation in kg. per hour, $\theta_n H$
$H_1 = 59.2$		$= 3280$
H_2	$3280 + 430$	$= 3710$
$H_3 = H_2 + 265$	approximately same as H_4	
$H_4 = H_2 + 342$	$3280 + 430 + 1470$	$= 5180$

TABLE 10 HEAT TRANSMISSION

H_n	θ_v Kg.	T_n Deg. Cent.	$T_n - t$ Deg. Cent.	$C = \frac{T_n - t}{\theta_v}$ Deg. Cent.	Corrected T_n' Deg. Cent.	Corrected $T_n' - t$ Deg. Cent.	Error $\phi = \left(1 - \frac{T_n'}{T_n}\right)$ PerCent
H_1	55.4	872	689	12.4	847	664	0.03 = 3
H_2	46.7	720	537	11.5	738	555	−0.023 = −2.3
H_3	14.9*	342	159	10.7	361	178	−0.053 = −5.3
H_4	12.3	243	60	4.9	331	147	

* Calculated value of θ_h.

$$H_1, \theta_1 = \frac{3280}{59.2} = 55.4 \text{ kg.}$$

and for

$$H_4, \theta_4 = \frac{5180}{401.2} = 12.95 \text{ kg.}$$

from which the following equations may be derived for the determination of a and b (with $R = 2 \times 3.68 = 7.36$ qm):

$$55.4\left(b + \frac{59.2}{7.36}\right) = a, \text{ and } 12.95\left(b + \frac{401.2}{7.36}\right) = a,$$

hence $b = 6.15$, and $a = 788$, and the equation expressing the law of evaporation may be expressed, in its first approximation, as follows:

$$_n = \vartheta \frac{788}{6.15 + \frac{H_n}{R}}$$

Now, since

$$\vartheta_2 H_2 = \frac{788 H_2}{615 + \frac{H_2}{7.36}} = 3710 \text{ kg.}$$

it follows that $H_2 = 80$ qm. Knowing H_2 it would be possible to calculate a, b and ϑ_n in the second approximation, but this does not appear necessary because, as the author shows, the first approximation gives sufficiently correct results.

In his investigation of evaporation processes in locomotive boilers the author proved that the transference of heat is proportional to the square of $T_n - t$, difference between the temperatures of the heating gases and the boiler water, which leads to the following equation:

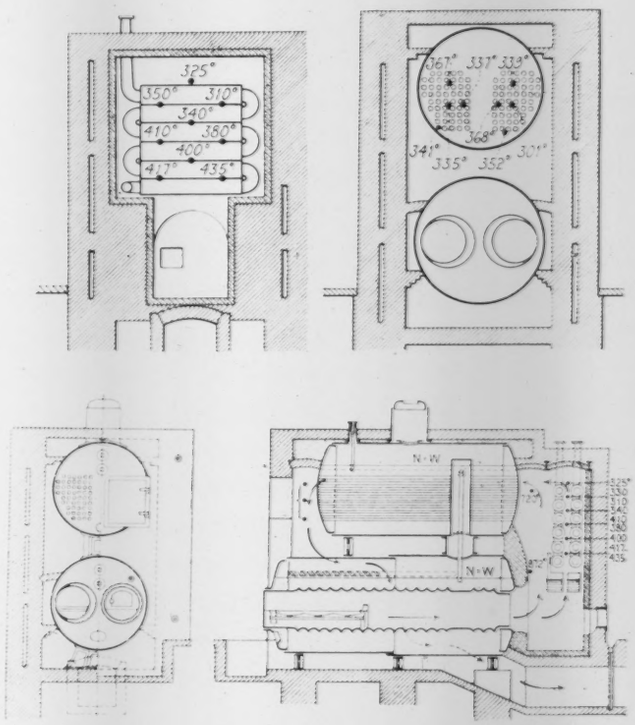


Fig. 16 Schwoerer Double Flue Boiler with Superheater

$$(T_n - t)c_p(1 + L)\beta = \frac{ab\lambda}{b + \frac{H_n}{R}} = \theta_n b\lambda,$$

where T_n is the temperature of the furnace gases at n, t the temperature of the boiler water (183 deg. cent. = 361.4 deg. fahr.); β the weight, in kg., of coal burned per hour per 1 qm. of the grate area; L the weight of the air required for burning 1 kg. of coal, and $c_p = 0.25$, specific heat of the heating gases. From this equation it follows that

$$\frac{T_n - t}{\vartheta_n} = \frac{b\lambda}{c_p(1 + L)\beta} = C$$

and that C is constant, since all the members of the right side of the equation are constants. Therefore, if it could be proved that in stationary boilers the preceding equation holds good, that would also show that the above enunciated law as to the magnitude of transference of heat applies to

stationary as well as to locomotive boilers. Table 10 shows the values obtained. The deviations of the first three values of C from a fixed average the author ascribes to unavoidable errors of observation and accidental influences. In third and fourth line the rapidly growing discrepancies are probably due to heat given up to the brickwork. By assuming for C the average value from the first two lines, $C = \frac{12.4 + 11.5}{2} = 11.95$, the author obtains a basis for the calculation of the last three columns of his table.

The last two equations may be used for various calculations, e.g., for determining the weight of flue gases. Since

$$\frac{T_n^1 - t}{\vartheta_v} = \frac{b^\lambda}{c_p(1+L)\beta} = 11.95$$

and the weight of coal burned per square meter of grate area per hour is 78.3 kg., it follows that

$$1 + L = \frac{6.15 \times 641}{11.95 \times 0.25 \times 78.3} = 16.9 \text{ kg.}$$

The author shows also how the efficiency of the boiler and coefficient of heat transmission may be determined.

Single Cylinder Engine with Drawing-off of Receiver Steam (*Eine Einzylindermaschine mit Zwischendampfentnahme*, C. Pfleiderer. *Zeitschrift des Vereines deutscher Ingenieure*, vol. 57, no. 51, p. 2030, December 20, 1913. 6 pp., 26 figs. *de*). The steam engine is better able to compete with other prime movers when the heat in the steam, after it has done its work in the cylinder, is further utilized for heating or cooking purposes. When for the latter purpose hot steam is required, it is taken from the receiver between the high and low-pressure cylinders, and it has been found that when a very large proportion of the total steam generated is taken for outside purposes in this way, the low-pressure part, with its consumption of space, interest and depreciation charges, lubrication, etc., ceases to pay for itself. In fact it may be said that when one-half of the exhaust steam is let out into the atmosphere with a pressure above one atmosphere, while the other half is used for heating purposes, the results are more satisfactory economically than when the low-pressure cylinder with its condensing plant are used. In small plants, of course, the single-cylinder engine is the naturally used type, while, with high superheat and elimination of all unnecessary clearances, it is as economical in its steam consumption as a multicylinder engine, so that often it is only the demand for steam for heating purposes that prompts the adoption of compounding. To obviate this, Thyssen & Company, of Mühlheim-Ruhr, Germany, have evolved the Missong engine, a single-cylinder engine with a provision for obtaining receiver steam for heating and other purposes.

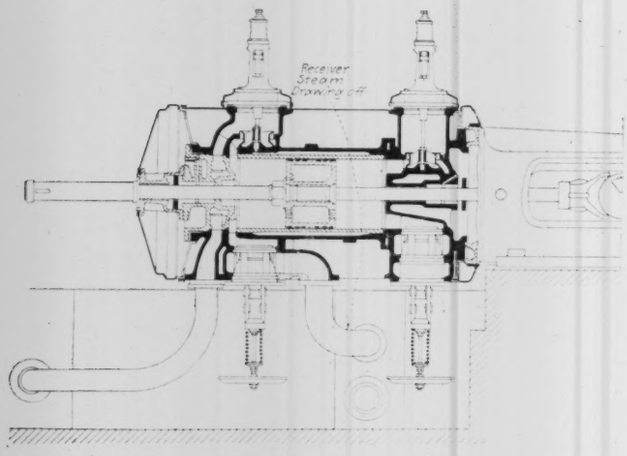


Fig. 17 Missong Single Cylinder Compound Engine with Receiver Steam Available for Heating Purposes

As shown in Fig. 17, the high and low-pressure cylinders are really combined in one, and lie on the two sides of a simple piston moving in a smooth cylinder. When the steam spaces on both sides are fully utilized, this arrangement corresponds to a compound engine with a ratio of cylinders as 1 : 1. With this ratio a large amount of receiver steam is available, while the engine has such a small low-pressure cylinder that the latter can work economically with what steam it gets. Further, as most of the oil is supplied to the low-pressure end of the cylinder, not only the lubrication can easily be maintained in perfect order even with large amounts of steam drawn off, but the steam used for outside purposes is comparatively free from oil, and may therefore be used direct, without previous oil separation. The difficulty of the proposed arrangement lies of course in the fact that when the demand for receiver steam is small, the small size of the low-pressure cylinder will intertere with the proper working of the engine, but the inventor obviated this by making the effective volume of the high-pressure cylinder variable in accordance with the demand for receiver steam.

The obvious way to do it was by varying the exhaust lead hand in hand with the admission. Fig. 18A gives an indicator diagram showing this system. Point I shows the exhaust lead when no steam is drawn off. The effective stroke in the high-pressure cylinder is here s_h, the effective volume ratio is $s_h : s_n$. During the remainder of the stroke s' the piston sucks only steam from the receiver, to throw it out again on the return stroke, which is uneconomical. With increasing admission in the high-pressure cylinder, which may be produced by an increase in the drawing off of receiver steam, the exhaust lead must decrease, and point II shows its limit for a drawing off of 56 per cent, with a 32 per cent admission in the low-pressure cylinder. When the governor acts at the same time on the admission and exhaust lead, all the processes of compounding will be reproduced in a single-cylinder engine, though with some losses, owing to the fact that part of the stroke is "dead." Another system was therefore adopted, with the variation in the high-pressure cylinder volume being effected through an alteration in the degree of compression (cp. Fig. 18B). When less steam is taken from the receiver, some of the steam let into the high-pressure cylinder is forced back into the live steam piping, i.e., the compression is increased, which is equivalent to a reduction of the high-pressure volume; the contrary expedient is adopted when the drawing off of steam is increased. In order to avoid formation of loops in the diagram, the admission lead is also placed somewhat in advance, so that the loop formation is reduced to the amount corresponding to the flow resistance in the valve gear. As shown in Fig. 18B, with no drawing off of steam the admission lead begins at I, the effective high-pressure volume is equal to s_h, the passive to s'. With increasing drawing off of steam, i.e., increasing admission, s_h increases and s' decreases, just as in the preceding case, which indicates that both systems of governing are in full accord with

one another. The Missong engine is therefore a single-cylinder compound engine, with possibility of using receiver steam, and the ratio between the high and low-pressure volumes varying in accordance with the consumption of receiver steam. Although the volume ratio of 1:1 is fully unsuitable for an ordinary compound steam engine, even when no receiver steam is drawn off, the characteristic of compounding is fully maintained, the work of the steam being divided between the high and low-pressure cylinders in a manner such that the drop in temperature in both of them is equal. Of course the back pressure due to the flow of steam back into the live steam piping represents a certain loss of energy, but that may well be overlooked since the engine is destined to work normally with the drawing off of receiver steam, and the ratio of cylinders convenient for this purpose does not permit of making the low-pressure cylinder work with the usual small admissions.

The problem of the valve gear (Fig. 19) in the Missong engine is somewhat complicated by the fact that not only the admission, but also the compression and admission lead in the high-pressure cylinder, are variable. The governor for the receiver pressure also takes care of the regulation of compression and admission lead as well as the admission on the high-pressure side, the latter decreasing as the compression increases. The regulation is accelerated through the variation in admission owing to the fact that it thus receives less steam when it wants less; losses of power through back pressure in the live steam piping are reduced, and exhaust lead of the high-pressure cylinder increased. *The influence of the pressure regulator is, however, limited to the high-pressure side only.* The velocity regulator adjusts the power output to the demand by varying the admission on the low-pressure side. This system of governing is claimed to give satisfactory results. Thus, when, with a decrease in the amount of steam drawn off from the receiver the pressure regulator sets in on the high-pressure side higher compression and smaller admission, the falling off in output is compensated for by the velocity regulator increasing the admission on the low-pressure side; more steam is taken from the receiver, the pressure in it falls, and the pressure governor begins to act in the same way as the velocity governor. A variation in load is also taken care of by the governors. If the load decreases, the velocity governor reduces the admission to the low-pressure cylinder; less steam is taken from the receiver, and the pressure in it rises; this causes an increase of compression and decrease of admission on the high-pressure side, with a reduction in the amount of steam entering into the engine.

The original article gives data of tests of the Missong engine with numerous indicator diagrams.

THE 15TH ANNUAL MEETING OF THE SOCIETY OF NAVAL CONSTRUCTORS (*Die XV-Hauptversammlung der Schiffbautechnischen Gesellschaft,* O. Flamm. *Schiffbau,* vol. 15, no. 5. Article not finished). The article contains full data of the paper read at the German Society of Naval Constructors by one of the directors of the Hamburg works of the Vulkan Company, Dr. Bauer, and the discussion which followed it. The main subject discussed in the paper is that of turbine blade ruptures. These ruptures, according to Dr. Bauer, are due, first to unsatisfactory material, and second to poor design and operation of the apparatus. As to the design, strict attention must be paid to proper dimensions of the blades, and to the provision of sufficient axial and radial clearances, especially when superheated steam is used. The blades should be interconnected by wire or bandages, and thus made to support one another. The reversing turbine is always a source of danger as far as the safety of the blades is concerned. As to the immediate cause of ruptures of blades, the author did not put much weight in the possibility of foreign bodies getting in among the blades and thus producing breakages; in most cases where such a reason was cited, the accident was probably due to some other cause. A steam screen in front of the admission port would in any case keep all foreign matter out. If such a foreign body did happen to get in, far less damage would

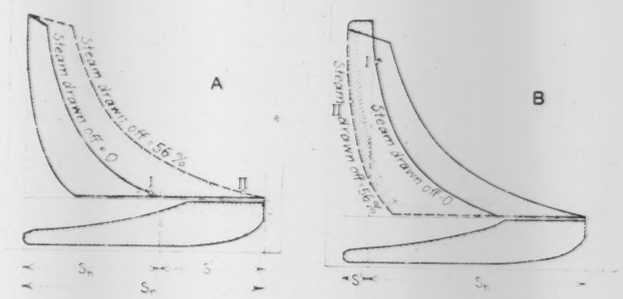


FIG. 18 INDICATOR DIAGRAMS ILLUSTRATING VARIOUS METHODS OF GOVERNING

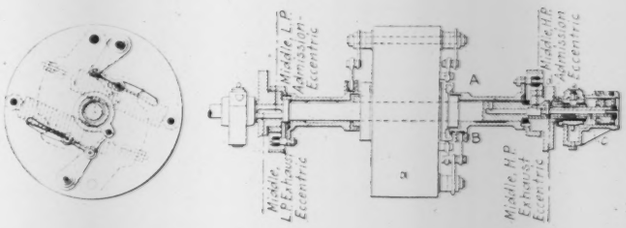


FIG. 19 VALVE GEAR OF THE MISSONG SINGLE CYLINDER COMPOUND ENGINE

be done if the blades were running in one direction only than if a back turbine were also being used. Improper operation was more often the real cause of accidents; under this head may be mentioned the action of water hammer, which is particularly likely to occur in plants having reversing turbines. As the manoeuvring apparatus has to be used particularly in harbors, accidents from water hammer are especially apt to occur there. If a large amount of water is thrown into the turbine from the boiler, owing to excessive boiling, no harm will be done as long as the turbine runs always in one direction; the critical situation arises only when large masses of water are thrown suddenly against the blading by the steam, as may happen at starting or reversing. For transmission from the turbine to the propeller the author recommended the Foettinger transformer in preference to gear transmission.

These views called forth considerable opposition. Mr. Roth, engineer at the Schichau works, did not share the speaker's view as to the dangers from the presence of a reversing turbine, and said that effective and convenient reversing turbines for reversing may now be built. The disadvantage of the transformer lies in its low efficiency, some 6 per cent below that of chain drive. Mr. Eggers, director of the

Schmidt Superheater Company, spoke briefly of his tests of a 10,000-h.p. Foettinger transformer; after a 14 days' uninterrupted run the tests were arranged so as to either break the transformer down, or show that it cannot be broken down; the apparatus stood the severe conditions of the test, and thus proved its reliability. All the speakers emphasized the fact that indirect drive was what was to be expected to be universally adopted in the future.

Alsacian Association of Steam Machinery Owners, Report of the Work done in 1912 (*Association alsacienne des propriétaires d'appareils à vapeur, Rapport sur les travaux exécutés en 1912, Bulletin de la Société Industrielle de Mulhouse,* vol. 83, no. 9, p. 697, November 1913. 82 pp. *gs*). The main work done by the association consists in the inspection of steam apparatus, either in the regular course of business, or by invitation of the owners, or finally on account of some accident which happened in a plant on the lists of the association.

In this report full data of such accidents, with their causes, are given, as well as general remarks on steam plant conditions in the district, and some data of tests carried out by the officers of the association. The following remarks are of general interest:

Steam piping is not covered by precise legislation, and is not therefore under the special control of the association or any other organization. Nevertheless there are just as many accidents due to steam piping as to steam apparatus proper. As the pressure and temperatures of steam tend to go up, high pressure piping becomes subject to considerable stresses due to internal pressure or expansion, and this makes it absolutely necessary, in order to avoid accidents, to use first-class metal and careful and sensible work in the installation of the piping. As a matter of fact, however, the piping is often very much neglected, and while in new installations all sorts of precautions are taken with the boilers and engines, very little interest is often shown as regards the safety of the piping.

It is in the manufacture of steam piping especially that autogenous welding is used. Pieces difficult to manufacture by forging or ordinary welding can be made by this process, and when used with discernment and sufficient care it is a great help in the installation of piping systems. But according to the council of the association this process is unsuited for use in systems carrying considerable pressures, pipes in which the longitudinal seam has been joined by autogenous welding. During the year to which this report refers, the association had a striking example of this fact in a case where the piping designed to carry exhaust steam at 4 kg. per sq. cm. (56.8 lb. per sq. in.) had to be replaced by weldless piping. Some of the pipes made by autogenous welding broke when the joints were put on. Another pipe opened during the operation along the weld a distance of 60 cm. (15 in.). It must be stated, however, that in addition to defective welding, the pipes in this case were not strictly cylindrical.

The association has been instructed by the International Union of Boiler Inspection Associations to study the influence of the circulation of water on the transmission of heat in economizers and has performed during the year 1912 a series of experiments, which, together with the experiments on economizers during preceding years, has given a considerable amount of material bearing on this subject.

The system of water circulation, i.e., the simultaneous ascension of water in the tubes and the horizontal flow of gases around these tubes, which has always been applied by Greene & Son, inventors of the economizers, has seemed unreasonable to certain designers. These have insisted on the necessity of a more systematic circulation and have either divided the feed heater into several sections, or have carried to the extreme the principle of the countercurrent circulation, in forcing the water to circulate alternately from bottom to top, and from top to bottom in a series of successive tubes. This question has caused an animated discussion which has been rather strengthened than appeased by the comparative tests which were made some five or six years ago at the mechanical laboratories of the Bavarian Association. The present tests have shown that, (*a*) the increase of the speed of water in the feed heaters increases to a small extent the coefficient of transmission of heat; and (*b*) all changes in the circulation of water with respect to the gases which approach the real countercurrent circulation, all other conditions being equal, increase the total quantity of heat transmitted and the efficiency of the feed heater; but this increase depends to a large extent on the relative dimensions of the feed heater with respect to the quantity of water and hot gases, in the sense that the larger the feed heater, the more reason there is for using methodically installed countercurrent circulation.

The report also contains material on steam turbine tests as well as fuel tests of various types of machines, and tests of Diesel engines.

ENGINEERING SOCIETIES

AMERICAN RAILWAY ENGINEERING ASSOCIATION

Bulletin, vol. 15, no. 161, November 1913, Chicago

The Air-Seasoning of Timber, Wm. H. Kempfer (Abstracted)
Rolling Loads on Bridges, J. E. Greiner
Discussion on Rolling Loads on Bridges (Various Authors)

The Air-Seasoning of Timber, Wm. H. Kempfer (67 pp., 63 pp., bibliography. *gp*). The article is composed from data obtained by the United States Forest Service and is very interesting as a clear presentation of all the material collected.

As regards southwestern woods, ties cut in January and February require from four to five months to reach a constant moisture content. As the season advances, the rate of evaporation is very much increased. Ties cut in May and June required a much shorter time to reach constant weight—from two to one month. Not much change occurs in this weight until November, while the November and December ties reach a constant weight in about six months. Very little difference was found in the rate of seasoning of black and of red pine, but the total loss of weight was usually greater for the black pines. This would be expected because rapidly growing trees generally contain more sapwood and hence more moisture than the slower growing trees of the same species. This applies, however, only to most coniferous woods, but not necessarily to the broad leafed trees or hardwoods.

Although climatic conditions of the northwest are different from those in the southwest and vary also throughout the region, the same grouping of the ties can be employed

in all places and the effect of the time of year when the tests are started is very evident.

Lodgepole pine in Montana cut in May, June or July was practically air dry in three months, and even if started in September it became fairly well seasoned before winter; but if started in winter it did not become dry until July of the following summer. The rainy season may also affect the rate of drying.

In the case of southern pines, the influence of variations in meteorological conditions with the time of year is also quite marked, although conditions seem favorable to a rapid drying throughout a large portion of the year.

The rates of seasoning for loblolly and short leafed pines at Silsbee, Texas, for example, resemble each other very closely, but the long-leafed pine dries a little more quickly. However, the total weight loss is much less. The southern hardwoods in general differ from the coniferous in the slower rate at which they lose moisture and the longer time they require to become air dry. Ties cut in the spring and early summer in Arkansas were far from dry when they ceased to lose weight at the approach of summer, and during the following summer they lost nearly two thirds as much moisture as during the first summer. Data on the rate of seasoning hardwood ties in the north are very meager. The author gives also data on seasoning poles and cross-arms which do not materially differ from the seasoning of ties.

As regards the factors which influence the rate of seasoning, the author refers to climatic and meteorological conditions, species, and form of timber, manner of exposure and soaking. Variations in the rate of seasoning among species may be due to differences either in moisture content or the permeability of the wood. As to possible deterioration of the wood while seasoning, the author points out that ties or other timbers sometimes decay before the end of seasoning, but it is believed that this can be prevented by piling timbers so as to dry rapidly. The tree should be barked as soon as felled and the timbers piled openly. On the other hand, however, quick seasoning is not always desirable, because timber cut and set drying in hot weather checks more seriously than in cold weather and sometimes becomes "case hardened" and very resistant to preservative treatments. Information is also collected on the degree of dryness obtainable, shrinkage of volume of the wood due to drying, specific gravity and weight of wood. The article is accompanied by numerous tables and diagrams.

AMERICAN SOCIETY OF BREWING TECHNOLOGY

Journal, vol. 4, no. 1, October and November 1913, Chicago

Deep Well Compressed Air Pumping, James P. Gillies (Abstracted)

Use of Superheated Steam for Boiling Beer Wort, and Detrimental Effect on Copper

DEEP WELL COMPRESSED AIR PUMPING, James P. Gillies (15 pp., 8 figs. *cdp*). The paper describes compressed air pumping on the air lift system. This method of pumping has been long considered to be very reliable and capable of obtaining the greatest quantity of water from a well of a given size. Usually, however, the air lift was installed only as a last resort under conditions that seriously handicapped it. It is only very lately that air lifts have begun to be installed in a proper manner and the high efficiencies now obtainable are due to the high state of perfection of the air compressors, better method of introducing the air into the eduction or water pipe, and to the proper proportioning of the pipes themselves. The modern air lift is so arranged that a constant stream of air and water is mingled, the air being broken up into small particles and an emulsion formed. This is forced through ventura to give the jet effect and each separate minute air bubble by its expansion carries its quota of water, resulting in a constant discharge with the minimum amount of slippage. The eduction pipe must be filled with air and water, and if it is too large for the amount of water, then a larger amount of air must be used to keep up the velocity.

Another thing that should receive attention is the enlarging of the eduction pipe towards the surface to allow for the expansion of the air upon its way to the surface. The changes, however, should not be abrupt and should not be carried to the extent that the air will be allowed to pass the water. The eduction pipe should be smooth. If the ends do not butt in the coupling but a short space is left between the pipe ends, swirls are produced and the air obtains an opportunity to slide past the water, which it has always a tendency to do.

The air lift system when properly installed may be very efficient even for deep well pumping. Thus the author quotes a case of several plants in Chicago where in each case the water is lifted more than 200 ft. at a cost that equals the best practice by any other means and in quantities unobtainable under the conditions in any other way.

As regards the cost of installation of the air lift, in small units, say under 300 gal. per min., it is slightly in excess of other competent methods. From 300 to 800 gal. per min. the cost is about equal, and above this limit the air lift has a decided advantage from the point of view of cost of installation. This is of course considering the total cost of plant, including the wells, the difference in favor of the air lift being due to the fact that fewer wells are required for an equal amount of water.

As regards maintenance of cost, the air lift once installed remains put indefinitely. Nothing comes into contact with the water except air and pipe. The only machinery used is located where most suitable, under the eye of the operating engineer, and any number of wells may be operated through the same compressor, provided its capacity is great enough, without regard to the location of the wells themselves. In addition to that, as far as the air lift is concerned, sand and solids in the water are not detrimental and do not have to be screened off. The air lift draws out the sand and sludge, enlarges the water bearing cavities and so increases the flow.

In the discussion which followed, G. J. Patitz pointed out that the air lift requires also a certain amount of attention, and it is necessary in most places to pull it out every two years or so, and often renew some sections of the piping used in connection with the air lift as they are usually subject to corrosion.

Mr. Christmann described some tests which he made at the plant of the Gottfried Brewing Company, with the deep well center pump and air pumping, of which the air pumping was very successful. The well, which is 12 in. reduced to 8 in. bore, 1658 ft. deep, was first fitted up with a motor-driven deep well center pump. After tests for several months, it was found that it could not give the amount

of water required. The proper sized air compressor was then installed and since then the system was running very satisfactorily, working 24 hours every day.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Journal, vol. 25, no. 4, November 1913, Washington

Description of the U. S. Fleet Collier "Jupiter," Lieut. S. M. Robinson, U.S.N.
Stresses in Marine Shafting, Ernest N. Janson (Abstracted)
Some Notes on Gyroscopic Action, Wm. L. Catheart
Development of the Modern Gas Engine, Commander J. E. Palmer, U.S.N.

STRESSES IN MARINE SHAFTING, Ernest N. Janson (30 p., 11 figs. *t*). Stresses in shafting of marine engines may be classified as, (*a*) known stresses, which are determinable by the ordinary laws of physics, and therefore may be allowed for; and (*b*) unknown stresses, which are not determinable from the ordinary engine forces, but may be established by directly measuring the torque by special torsion meters, such as would indicate the fiber displacement of the shaft continuously for one or more revolutions.

The known stresses may be enumerated as follows: (*a*) Stresses due to forces exerted by the pressure of the steam in the various engine cylinders; (*b*) stresses due to inertia of moving parts of machinery; (*c*) stresses due to the bending influence in the crankshaft by direct action of steam forces and in the propeller shaft by the weight of propellers and pitching of the ship. These stresses are fully discussed in the article and various test data given.

Among the "unknown" stresses are to be found the following: (*a*) torsional vibration stresses; (*b*) stresses brought on by distortion in alignment of bearings either as a result of wear in the bearings or weakness of hull, and in foundations; (*c*) stresses resulting from defects in the material, or running afoul, or reactions of propeller due to pitching. The last two types of stresses are allowed for by employing "safe" stresses per square inch of section in the calculations used to determine dimensions.

Torsional vibrational stresses are not commonly allowed for either as an additional stress or by a reduction in the strain permissible per square inch of material. Regarding the additional stress brought on shafting by want of alignment, John H. MacAlpin in his paper on Crank Shafts[1] shows that when the bearing immediately forward of the after crank is only 0.001 in. out of alignment, there is an increase of 0.3 of 1 per cent in the strain beyond what is due to ordinary forces.

The subject of torsional vibrations is discussed on the basis of the paper of Herrman Frahm,[2] as well as the papers of G. Bauer and L. Gümbel, the author applying the formulae there obtained to the case of U.S.Ss. *Connecticut, Delaware*, and *Pennsylvania*. He points out that the critical number of revolutions of the fourth order of many engines of naval vessels often constitute also the cruising speed of the ship; and although the power at this speed is greatly reduced, the stress of the shafting due to the equivalent combined twisting moment becomes approximately equal to shafting stresses as large as when the engine is developing the full power. These stresses fluctuate between zero and the maximum value in one direction, and zero and a maximum value in the opposite direction, the twisting action of the shaft thus being reversed several times during each stroke, the number depending upon the type of engine.

The first accident to one of the crankshafts of the U.S.S. *Connecticut* occurred after having made approximately 34,150,000 revolutions with an average stress of about 14,000 lb. per sq. in. The existence of a considerable increase of stress in shafting of reciprocating engine shafts due to synchronous torsional vibration at normal, or cruising speed of naval vessels, and to overloading or other conditions such as sudden reversal, striking of floating bodies, etc., renders it reasonable to assume that shafting with a design shear stress of 10,000 lb. per sq. in. of section becomes severely overstrained; this design stress may be lowered in the interest of greater safety even at a sacrifice of greater weight or cost of increased dimensions.

It is interesting to note that the designed shear stress in line and propeller shafting for marine steam turbine installations seldom exceeds 6500 lb. per sq. in. of section of steel of 80,000 lb. tensile strength when working merely at a uniform torque. This shafting, therefore, in comparison with reciprocating engines, is working under far more favorable conditions with the result that accidents in the form of breakage are of rather rare occurrence.

The problem of making a meter for indicating torsion in the case of reciprocating engines is made somewhat complicated by the fact that the forces acting in this case create a continuous to and fro motion, and what may be termed "twisting and untwisting" of the shaft, the magnitude of which varies continuously during every revolution and between them. Such meters have, however, been made of a combined electromechanical type with some degree of success, but have not been extensively applied, owing to the necessity for considerable skill on the part of operators, and errors in interpreting records. A purely mechanical torsion meter with direct shaft connections giving a continuous record of torque for a number of revolutions would be of great value in obtaining reliable data in connection with the rather uncertain and difficult subject of calculating the stresses in marine engine shafting.

THE CONCRETE INSTITUTE

Transactions and Notes, vol. 5, p. 1, October 1913, London

The Settlement of Solids in Water and Its Bearing on Concrete Work, J. S. Owens
Steel Frame Buildings in London, S. Bylander
Economy in Reinforced Concrete Design, John A. Davenport
The Strength of Cement, H. C. Johnson (Abstracted)
Reports of the Reinforced Concrete Standing Committee (Cracks in Concrete and The Surface Treatment of Concrete)

THE STRENGTH OF CEMENT, H. C. Johnson (40 pp., 2 diagrams, 2 figs. *eA*). The author made tests of 15 different brands of cement used in paste, mortar, and concrete, and gives full data of these tests indicating the various brands, mainly English, by numbers. Some general conclusions arrived at are here reported.

Fineness, apparent density and specific gravity have been found to be closely related to one another. While the test for fineness is always valuable as a guide to a carefully pre-

[1] Journal of the American Society of Naval Engineers, November, 1896.

[2] Reprinted, vol. 14, Journal of the American Society of Naval Engineers.

pared and economical cement and is a constant quantity for a given cement, the apparent density and specific gravity vary with age. But when the approximate ages of cements sent for a comparative test are known, the three tests are all valuable: fineness, since it gives the percentage of binding material in the whole; the apparent density, because it indicates the volume for a given expenditure; and specific gravity, because low ones indicate ill-proportioned binding material for mortars and concretes, although they may be satisfactory for paste.

As regards cement mortar tests, the value of fine grinding has been brought out as well as the superiority of the mortar test over the paste test as a guide to the binding value. Certain general points have also been brought out: A decrease in strength in tension at 90 days as compared with 28 days does not necesarily indicate a decrease in compression. At 90 days the difference in strength between specimens with high and low percentages of water is very small, and in the case of the air-cured specimens it seems an advantage to have a higher percentage of water. The higher percentages of water have a greater effect on the tensile strength than on the compressive. But all cements do not give their greatest strength with the minimum amount of water it is possible to use. While the low percentages of water give a higher strength in the earlier ages, in the majority of cases there is very little falling off at 90 days due to the increase of water. In fact, one might reasonably expect that with a good cement the higher percentages would eventually produce a stronger material.

Concrete tests have given a strong argument against purchasing cement by weight and using it by volume. In the case of a light cement, a greater volume is received for a given weight. It is then used by volume with the result that the job suffers and the contractor benefits, the reverse taking place when a heavy cement is used. On the other hand, a heavy cement, if the specific gravity is high, is naturally coarser and then the job suffers as well as the contractor—the job, because the percentage of binding material is reduced, the coarse particles having practically no value, and the contractor, because he receives by volume a much smaller quantity for his ton.

The author also found that good strength in paste was not a proper indication of good strength in concrete. The best tests of a cement value for reinforced concrete or similar work are mortar compression cured in water and mortar compression cured in air, any cement having a higher value in air than in water to be condemned. For a given expenditure on cement, a first-class material will allow a saving, since there will be less cement to pay carriage on, less cement to handle, and at least as strong a concrete.

The author considers the system of selling cement in paper bags, as done in the United States, preferable to the use of canvas bags, as is the custom in Great Britain. Complete data of the tests with diagrams are given in the original article.

SOUTH AFRICAN INSTITUTION OF ENGINEERS

Journal, vol. 12, no. 4, November 1913, Johannesburg

Air Consumption and Maintenance Costs of Rock Drills, E. G. Izod and E. J. Laschinger (Abstractd)
Are We Becoming Too Automatic? Roger Price
Ventilation of Mines, W. Pile

AIR CONSUMPTION AND MAINTENANCE COSTS OF ROCK DRILLS, E. G. Izod and R. J. Laschinger (13 pp., 4 figs. *ps*). Of all the means for the transmission of power in general use for industrial purposes, compressed air is the most abused, or, one might perhaps better say, carelessly handled, and wasted. Since, at the present time, compressed air to a very large extent is directly purchased by many mines as power delivered at the shaft head at so much per unit, the subject of air consumption and economy in the use of air has again received further attention. As the air power used on the Rand is intended primarily for actuating rock drills, it is very important that the air consumption of these machines should be very thoroughly studied by engineers. Comparatively little is known about rock drills; if these machines had received a fraction of the thought and attention bestowed upon machine tools in the fitters', carpenters' and boiler-makers' shops, the history of the development of the rock drilling machine would have been a very different story and the machine itself would have attained a state of perfection and economy unknown today.

The mines under the control of the Central Mining and Investment Corporation, Limited, and the Rand Mines, Limited, purchase nearly the whole of their air power from the Rand Mines Power Supply Company, Limited. Against this consumption of air power, there is to be set the work done. Each mine keeps a record of the "machine shifts" worked underground by the rock drills of various makes and sizes and also a record of winches, pumps, etc., which are driven by compressed air. All these machines are then brought down to the standard rate of a 3¼-in. machine shift. This 3¼-in. machine shift standard represents the work that should normally be performed by a rock drill with a 3¼-in. cylinder working as usual during an 8-hour mining shift. With regard to the machine shifts actually worked in drilling rock, separate records are kept of stoping and development shifts on each mine showing the air consumption per individual shift.

It is well known that the amount of air consumed per development shift is greater than per stoping shift. By plotting the air consumption of each mine for each month per 3¼-in. machine shift in a position which corresponds to the ratio of development shifts to total shifts, points are obtained which show a mean line of air consumption and which indicate whether at any particular mine more or less air is being consumed than the average to be expected. With regard to mines which take more air than the mean mimimum as shown on the diagram, one must not at once jump to the conclusion that air is being wasted. On mines with wide stopes where deep holes are drilled, more air is used per machine shift and yet with greater economy in so far as breaking ore is concerned; hardness of rock, width of stope, footage drilled and other factors enter into the problem. At the same time a high air consumption when shown on the comparative record should form the cause of a serious investigation. Also, since the miners do not usually take the trouble and extra care to save air, and to see that all joints are tight and hoses in good repair, there is need for constant care and supervision. The fact that large savings in the air power bill of the mines may be effected by paying attention to this matter of air consumption is given by the following Table 11, which shows a progressive diminution of the air power required on the mines of the Central Mining-Rand Mines group for 1912.

TABLE 11 TOTAL DRILL SHIFTS, TOTAL AIR UNITS AND UNITS PER DRILL SHIFT DURING PERIOD JANUARY TO DECEMBER, 1912

Month	Equivalent $3\frac{1}{4}$-in. Machine Drill Shifts including Pumps and Winches	Total Air Units	Units per Drill Shift
January	73,926	12,018,587	163
February	69,887	11,072,207	158
March	78,887	12,555,015	159
April	75,980	11,272,770	148
May	81,548	11,919,934	146
June	73,839	11,287,577	153
July	82,252	11,561,971	141
August	81,161	11,333,228	140
September	75,581	10,832,301	143
October	80,510	11,339,470	141
November	79,862	11,037,958	138
December	78,545	10,813,549	138

The improvement as between January and December shows a saving of over one shilling per machine shift in the air power cost.

The method of assessing work done by the arbitrary standard of the $3\frac{1}{4}$-in. machine shift is no doubt somewhat crude, but it was devised as a beginning for making comparisons to suit present conditions on the Rand. Separate air meters should be permanently installed on each working level of a mine and at each point where air is used for specific services. This would enable the engineer to find out at once where air was being wasted or used in apparently excessive quantities. Strict investigation at particular points could then be carried out and leakage or waste hunted down to its source. Certain expenses would be incurred. If, however, one reflects on the elaborate organization dealing with the electric power on the mines it is certainly surprising that the air power is not attended to in the same way.

Whatever the make or type of drill, there is one point which is common to all and which deserves the closest attention of the mechanical engineer on the mine: that is the condition of the drill (mechanically considered) before it goes down into the mine, and the repairs and renewals which are made from time to time, especially in view of the fact that the rock drill has rough work to do, is roughly handled by persons who, in many cases, have no mechanical knowledge, and that it has to work under the severest conditions that test any machine and militate against economy over a prolonged period.

In this connection the author refers to the system of rock drill maintenance introduced some five or six years ago at the Village Main Reef Gold Mining Company, Limited. This system consists of bringing every drill regularly to the rock drill fitting shop, overhauling thoroughly in all its parts, and particularly in finishing up the cylinders with reamers, and grinding down the pistons to an accurate fit within a few thousandths of an inch, and thus standardizing cylinders and pistons. Besides this, a record is made of each machine in a book kept for the purpose, and when from the records it appears that the machine has been in the mine for longer than three months, that machine is brought to the surface for overhauling, whether the miner likes it or not. There is no doubt but that the enforcing of this system has given this mine its fine record on air consumption.

A short resumé of the result of these tests is given in Table 12, from which it will be seen that the state of repair of the machines on the various mines is reflected, first in the great difference in relative air consumption on the various mines, and, secondly, in the case of the last two tests, the difference on the same mine between the machines in ordinary state of repair and after having been newly repaired for the purpose of comparison. The important point about the overhauling of rock drills is in connection with the true bore of the cylinder and good fit of the piston. The points which these tests do prove is that a very neat fit of the piston is essential to economy in air consumption. Some may be of opinion that these close fits of the piston in the cylinder will cause trouble in practice, but the best answer to that is the fact that this close fit has not caused any trouble in some years' experience at the Village Main Reef Mine. The sticking of the piston is caused by front bushing being too tight or by a bent piston rod.

TABLE 12 RESULTS OF TESTS ON DRILLS

Mine	State of Repair of Drills	Cu. Ft. of Air per Min. of Drilling Time	Relative Consumption	Average Drill Speed, In. per Min.
Village Main Reef	Ordinary	$103\frac{1}{2}$	100	1·27
A	Ordinary	122	118	1·20
B	Ordinary	137	132	1·80
C	Ordinary	153	147	1·29
C	Newly repaired	120	116	1·30

In the early portion of 1912 investigations were made into the cost of operating machine drills, and figures were obtained of the cost of maintenance of drills and of the cost of air used for drilling. It has been shown that the air units per equivalent rock drill machine shift have decreased due to the attention to various details of the drills, leakages, etc.

FOREIGN REVIEW AND REVIEW OF THE PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

THE man who can make twice as many pounds of steam from a pound of coal as was made before would, in a way, confer on humanity almost as great a benefit as the man who makes the proverbial two blades of grass grow where one grew before. Whether the new Brünler type of boiler, with the flame projected directly under the water, does it, cannot be yet considered to be established by properly conducted tests, but it appears to be an invention having important possibilities.

THIS MONTH'S ARTICLES

At the basis of modern power generation lies the great question of fuel, and what Sir Roverton Redwood, a prominent British authority on oil, says with respect to the future possibilities of liquid fuel, is of particular importance in this country where the Diesel oil engine is now being introduced. In the same connection the article of Praetorius will be of interest. Hellman shows how by a proper design of admission valves and proper use of the scavenging process the output of a gas engine may be increased approximately 25 per cent. at the cost of only a slight increase in power consumption at the scavenging blower.

The section on Steam Engineering is of particular interest in this issue. Gwosdz describes the Greis smoke consuming apparatus and method of smoke prevention (improved type). Another abstract tells of the locomobile driven central station in Wiborg, Finland, remarkable for its economic design and low cost of power production in pounds of steam per kilowatt generated. In fact the plant is so designed that it works practically all the time at its most economic loads, and is at the same time perfectly able to take care of all peak loads.

The report of the German investigation of the turbine situation in that country is concluded: it gives interesting data as to the turbine costs, efficiency at partial loads, and power reserves in turbine driven central stations (the latter appear to be suspiciously large). From a Russian paper is abstracted the beginning of an investigation on loss of heat of locomotive boilers through cooling, in which, probably for the first time, an attempt is made to fully consider the variation of the coefficient of cooling as a function of the shape of various parts of the locomotive surface, its speed of motion, influence of wind, etc. The abstract will be continued in an early issue. The question of the influence on the life of boilers of impurities in the feedwater, and in particular the way their presence produces bulging of tubes, is discussed in two reports presented to the general meeting of the International Association of Boiler Inspection Societies; in the next article A. Gramberg thoroughly investigates the processes of water heating by steam, and compares, for output and efficiency, the parallel flow and counterflow principles.

In the section on Materials is given an abstract of an investigation (in Austria) on telegraph poles affected by fungus, and an abstract of an article by Professor E. J. Coker, of London, on optical methods of testing stresses in structures, giving the theory of this new method and showing some of the apparatus used.

In the second section of the Engineering Survey, the Engineering Societies, is presented a report to the American Concrete Institute, a new organization with a big field before it, on methods of tests of concrete materials. In papers before other societies are described a drag line excavator, tests of ten ton ice machine, and commercial tests of internal combustion engines (with a discussion of the importance of knowing the mixture strength for properly understanding the action of an engine); R. Thomas, in a paper before the Institution of Marine Engineers (British) gives valuable data on some gyroscopic phenomena.

FOREIGN REVIEW

Firing

GREIS SMOKE-PREVENTING DEVICE (*Rauchverhütungsapparat System Greis*, Gwosdz. *Zeitschrift für Dampfkessel und Maschinenbetrieb*, vol. 36, no. 50, p. 607, December 12, 1913. 3 pp., 8 figs. *d*). The article describes an improved type of a smoke-preventing apparatus devised by Jakob Greis, as well as an older type of this apparatus. The principle of the apparatus is illustrated in Fig. 1A, which shows the position of the parts immediately after charging the fuel, with the door closed. Before the fuel was charged the valve *a* was in its highest position, thereby providing for complete closing of the opening in the fire door, while the weight *b* was in its lowest position, the entire apparatus being therefore cut out. When the fire door is opened, the valve *a* at first remains in its highest position while the weight *b*, with the piston of the brake cylinder *c* rigidly connected with it, is drawn upwards and comes to its highest position; thereby the lever of the steam stop valve *d* is raised so that the steam can flow freely from the boiler through the pipes *e*, *f*, *h*, and the nozzle *g* over the fire, and through *i* under the grate in the form of a fine steam vapor.

When after the shifting of the fire and charging of fresh fuel the fire door is closed again, the weight *b*, on account of the resistance of the fluid in the cylinder *c*, still remains in its highest position, while the valve *a* comes to its lowest position shown in Fig. 1A. This provides for the opening in the fire door being opened and for the admission of the air to the fire. But in doing that, the air strikes the hot plate *k* provided with small openings and reaches the fuel considerably preheated. The steam coming out from the nozzle *g* forces the fresh air on to the fire, and at the same time the particles of coal and flue gases, which are all the time in turbulent motion, mix very closely with the steam and fresh air and are fully burned up either on the fire itself or in the flue passages. This action is helped out by the action of the steam entering through nozzle *i*. The weight *b* presses on the liquid in the brake cylinder *c* which gradually passes through a little adjustable valve at the bottom and a special passage into the free space above the piston. The weight therefore gradually comes down and forces the valve *a* upwards which shuts off the admission of fresh air. At the same time the steam valve *d* is also closed. When the valve *a* reaches its highest position and the weight its lowest position, the apparatus has ceased to act, but begins all over again when the fire door is opened anew.

In the improved type of apparatus the brake cylinder has been built much shorter than before, owing to the use of double rolls, which gives a more convenient position and shape to the counter weight and makes the entire apparatus much shorter and more compact. The entrance of steam into the valve *d*, Fig. 1B, is no longer from below with a lateral exit, but the reverse: the steam comes in from the sides and goes out downwards. The method of regulating the brake liquid is also changed: the piston rod of the brake cylinder piston has large openings for letting through the liquids (oil) and a plate valve is located under the piston. The operation in the latest type is as follows: As

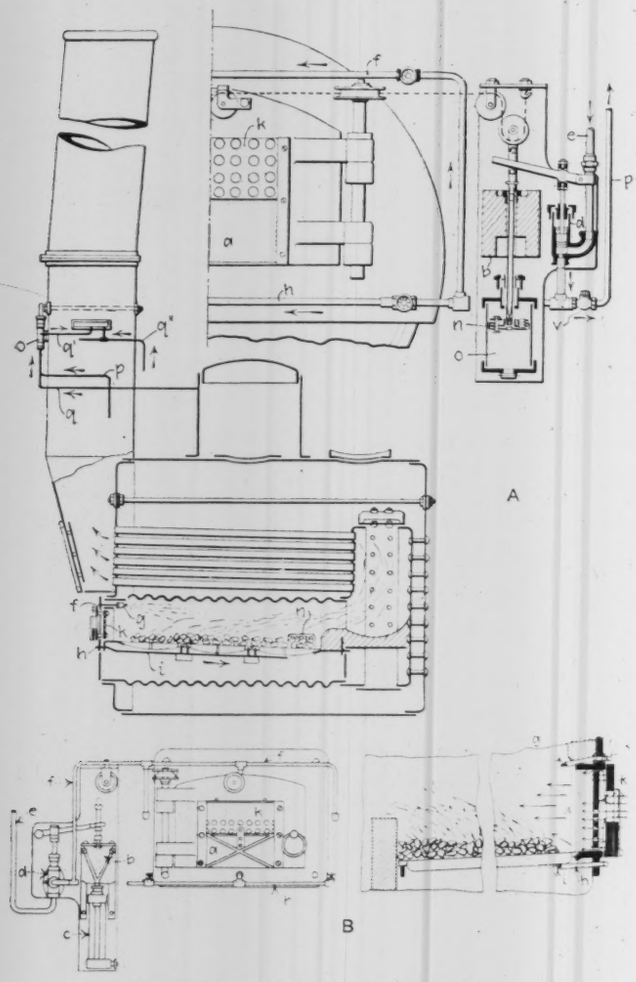


Fig. 1 Greis Smoke Preventing Apparatus

soon as the weight *b*, with the piston connected to it, is drawn up by the opening of the fire door, the plate valve falls down and opens the large openings in the piston to the free passage of the liquid. As soon as the counter weight begins to act on the brake liquid, the plate valve closes the large openings in the piston and the liquid must flow upwards through the hollow piston rod and regulate the valve *m* therein. In order to flow out again through the little holes in the piston rod above the piston, the slower or faster sinking of the weight *b* may be regulated by hand by means of a spindle traveling in the hollow piston rod, the latter being protected from bending or jamming.

In connection with this apparatus, special provision is made to take care of such soot and ashes as may still be carried off by the flue gases. It consists of a cylinder provided with two bores of unequal dimensions and corresponding pistons. The piston rod, which at the same time acts also as a piston for the smaller bore of the cylinder, is given a form such that its lower part may be used as a valve and the upper part as a geared rod. The larger bore of the cylinder *o* is connected with the pipe *p* and the smaller bore with the pipes *q″* and *q′*, while in the dividing wall between the two cylinder bores are located the small passages *r*. In the smokestack a dividing damper, *s*, is provided, having a little gear wheel in mesh with the geared rod of the piston; further, a combined water and steam nozzle, *t*, located at the smokestack at right angles to cylinder *o* and connected by the pipe *q′* with the cylinder *o* and by the pipe *q″* with the water tank. There is also a water pocket, *u*, on the side opposite to the location of the nozzle *t* and placed in a cut in the smokestack wall. It is connected with the steam valve *d* of the smoke-preventing apparatus only by the pipe *p* and receives besides fresh steam from the boiler through the pipe *q*. The operation of the apparatus is as follows: When the smoke-consuming apparatus is not in action, all steam admission is cut out and the dividing damper *s* in the smokestack is in its vertical position, thus affording a free path to the hot gases rising through the smokestack. But as soon as the fire door is opened, the steam stop valve *d* is opened also and the steam can freely flow through pipe *f* to valve *g* over the fire, pipe *h* to nozzle *i* under the grate as well as to nozzle *n*. It can also reach the cylinder *o* through pipe *p* and there raise the piston, the latter by its gears turning into horizontal position the damper *s* so that a part of the gases has to go through the water pocket, which is of such dimensions that by this arrangement the cross-section of the smokestack is not reduced. At the same time the live steam pipe *q* and the pipe *q′* leading to the combined water and steam nozzle *t* are opened, so that the steam coming through from the boiler or through the live steam piping can freely flow through pipes *q* and *q′* and nozzle *t* into the water pocket. By the suction of the steam in nozzle *t* water is sucked in through pipe *q″* and is mixed in the nozzle *t* with steam and is drawn out through the smokestack into the water pocket in the form of a mixed steam and water fog. This steam and water fog flowing at considerable speed in a state of fine division strikes the gases rising upwards and by its action the unconsumed smoke and soot particles as well as ashes drawn up by the fuel gases are saturated with wet steam and sink in the water pocket, while the clean gases pass out into the air through the smokestack.

This process of washing the hot gases flowing through the smokestack continues as long as one of the smoke-consuming apparatus on the boiler is in operation. The apparatus does not act until the fire door is opened, which represents the beginning of the period when the conditions are particularly favorable to an evolution of black smoke.

Hydraulics

New Method of Graphical Presentation of the Fundamental Equation of the Turbine Theory (*Eine Neuerung in der zeichnerischen Darstellung der Hauptgleichung der Turbinentheorie*, A. Pfeiffer. *Zeits. für das gesamte Turbinenwesen*, vol. 10, no. 36, p. 561, December 30, 1913.

3 pp., 7 figs. *t*). Interesting article, not suitable for abstracting. The author shows how, by an assumption of certain auxiliary values, the normal Camerer diagram for water turbines may be simplified; thus, while the Camerer diagram requires the determination of eight points, the author's diagram may be drawn with only five points, and with greater precision.

Internal-Combustion Engines

Tests at the New Testing Laboratory of the Automobile Club of France (*Les essais du nouveau laboratoire de l'Automobile-Club de France*, G. Lumet. *La Technique moderne*, vol. 6, no. 1, p. 5, January 1, 1914. 3 pp., 6 figs. *d*). The article describes the new laboratory for testing automobile engines and making other tests in connection with automobiles, installed by the Automobile Club of France in its new house at Neuilly-sur-Seine. One of the first problems of such a laboratory is to make provision for the convenient placing on the testing stand of the engine to be tested. In the present case, this problem has been solved in the following manner: The engine is brought into the testing room on a light truck which can carry about 2 tons. To be properly tested, the engine must be placed on the stand conveniently with respect to the brake arrangement, for which purpose each stand is provided with universal brackets designed in a manner such that the engine may be properly placed no matter how wide apart may be the bearing screws. The engine jacket must be cool; the gases of combustion taken away and necessary electrical connections established. There is therefore quite a complicated system of connections and the pivoted bracket held against the wall is arranged so that water, electrical current and exhaust pipes, etc., are all conveniently located. Some of the special appliances used in this laboratory are of particular interest: First, there is a stand for testing the thrust of the propeller at a fixed point. Connected to the propeller is a calibrated speed gear change to which is directly coupled a dynamometer for measuring the force as used, a device recently adopted by engineer Sabatier on the Bayard-Clément dirigibles.

For measuring oscillation effects, a trepidator is used consisting of a heavy plank carrying a small dynamo which is provided on the axis with a heavy mass located eccentrically with respect to the axis of the dynamo. This plank is supported at its extremities in a manner such that when the dynamo begins to rotate, it is given different oscillations which may be measured by an acceleromometer. (The Auclair and Boyer-Guillon type is used.) This apparatus, as well as the vibrometer of Guiche-Carlo-Bouret is used to determine the properties of various suspensions of automobile carriages and the influence of oscillations upon their structure, for the determination of which a mixed commission is appointed, consisting of members of the Central Society of Architects and the Technical Commission of the Automobile Club of France.

In connection with these tests of various engines, on the outside of the laboratory a number of fans placed under awnings are provided. The cardan shafting connecting the engine of the fan passes through a special window in the wall of the laboratory. One of the integrating revolution counters has also a shaft which passes through the wall, while close to the counter is placed a controller of angular speed designed by Ventou-Duclaux. This apparatus has a little dynamo which takes care of the unrolling of a strip of paper while two electro-magnets record on this strip of paper every thousand of revolutions and every minute of time from the instant the current is switched in.

The article describes also the apparatus designed for the investigation of accessories such as carburetors, mufflers, and ignition, as well as for the investigation of fuels.

Fuel Supply and Governing of Heavy Oil Engines (*Brennstoffzuführung und Regulierung der Schwerölmotoren*, Praetorius. *Der Motorwagen*, vol. 16, no. 34, p. 857, December 10, 1913, and vol. 17, no. 1, p. 1, January 10, 1914. Serial article, not finished, *d*). In the present article the author proposes to investigate the methods of fuel injection and governing of heavy oil engines which he does by describing a number of systems used in this connection and from time to time indicating data of tests. Only such of the systems as are comparatively little known in this

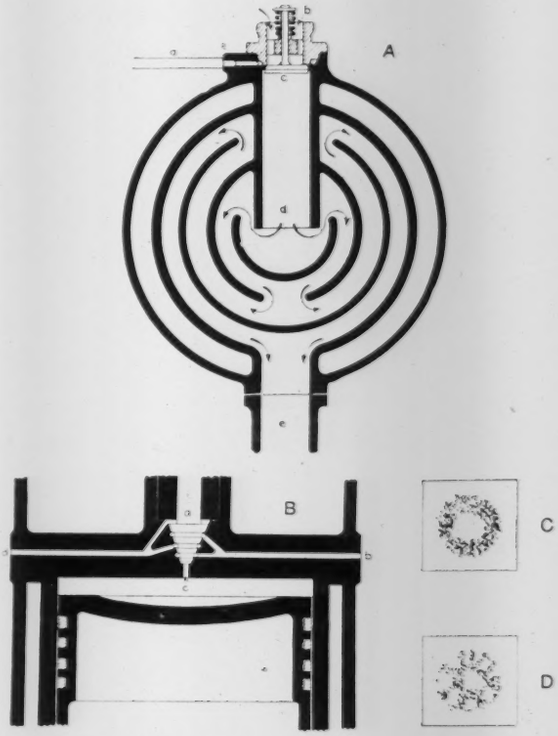


Fig. 2 Fuel Regulation Devices, Heavy Oil Engines

country will be here reported. One of the main problems is to produce a close and uniform mixture of the fuel and air. The Dürr Patents Company uses the device shown in Fig. 2A for this purpose, the fuel entering through *a* and the air through *b* with the valve *c* acting as an atomizer. The mixture is then conducted by pipe *d* into a labyrinth arrangement where it moves in the directions indicated by the arrows and where it is expected to become more intimately mixed. The mixture flows out by the pipe *e*.

A different system is used by Hindlmeier, Fig. 2B. The fuel valve *a* is provided on its seat with several grooves, alternating ones of which take up air and fuel. The fuel is brought in by *b*; compressed air by *d*. When the valve is lifted the air flows in between the fuel streams and forces it violently into the combustion chamber through the opening *c*, which results in the production of a good mixture.

Since a nozzle device is used in several types, the author gives a simple method for testing whether the nozzle is clean or partially clogged up. He recommends the taking off of the cover of the nozzle and instead of the plate *H* (he refers in this case to the Bergsund type of vaporizer, for which see *The Journal*, November 1912, p. 1882), a piece of paper is placed in front of the nozzle opening, and a short quick stroke of the fuel pump throws against this piece of paper a certain amount of the fuel. From the appearance of the deposit on the paper one can see whether the nozzle is clean. Thus the deposit shown in Fig. 2C indicates a partially clogged nozzle while that in Fig. 2D shows a clean nozzle.

NOTE ON THE COMPRESSION OF REAL GASES (*Note sur la compression des gaz réels*, H. Brot. *Revue de mécanique*, vol. 33, no. 6, p. 551, December 31, 1913. 9 pp., *mt.*). Article not suitable for abstracting. The author attempts to apply the usual thermodynamic equation derived for perfect gases, to real gases, assuming that the latter follow the van der Waals equation, and obtains some interesting results. Thus (*a*) he proves that: the heat produced by the compression of a real gas is equal to the sum of the work of internal pressure and the external pressure on the gas; and (*b*) he derives the equation of the adiabates of a real gas, general equations of transformation, and determines the mechanical work necessary to produce an isothermal compression of a real gas, as well as that for producing a non-isothermal compression ("if the initial and final pressures are low, the work of adiabatic compression of a real gas is less than the work of adiabatic compression of the same gas assumed to be perfect and under the same conditions of initial and final volume").

INCREASE OF SPECIFIC OUTPUT OF FOUR-STROKE CYCLE GAS ENGINES (*Steigerung der spezifischen Leistung von Viertaktgasmaschinen*, W. Hellmann. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 3, p. 105, January 17, 1914. 3 pp., 11 figs. *de*). The present article describes the constructional details of design to increase the output of a gas engine by about 25 per cent, continuously, at a cost of an additional expenditure of power of about 2½ per cent on the scavenger blowers, while, as the author claims, notwithstanding this increased output, the engine works at exhaust pressures not higher than other large gas engines (which is due to the fact that the compression space is only moderately increased). The thorough scavenging and the charging of the cylinder with gases and mixing air at atmospheric temperature reduces all the temperatures still farther, as modern experiments have shown. By this means essentially bettering the utilization of the heat content of the gas is obtained. A thorough scavenging is secured by giving generous dimensions to the cross-section of passages for the compressor air (see Fig. 3A) by giving sufficient time for scavenging processes Fig. B, and by using scavenger air at a pressure of 2500 mm. (100 in.) water. Fig. A shows the admission valve gear for compressed air scavenging and quality regulation for a large gas engine with an admission valve of 410 mm. (16.2 in.) in diameter. The external drive of the gear is in accordance with the general design of scavenger in large gas engines. The regulation of the gas supply to the engine by means of a gas flap valve actuated by the governor has already proved its suitability in numerous cases. The admission valve is connected with the seat and guided in the usual manner so that all three can be taken out together from the valve chest. On the valve spindle sits a freely movable cast-iron air piston *a*, which is connected with the mixing-air and compressed-air valve *b* by means of two hollow steel carrier pins, which have on their circumference turned out ringed grooves in which grip corresponding springs belonging to the cast-iron mixing-air and compressed-air valves. The two carrier pins move in the slides *d* of the air cylinder and prevent rotation of the air piston, while the compressed air valve cannot rotate owing to a key screwed into the cover of the admission valve casing. A screwed in and easily accessible pipe *e* conducts the compressed air to an annular passage *f* in the bottom of the air cylinder, governed by the small piston valve *g*, located on the admission valve stem.

The arrow *h* indicates how the compressed air comes under the air piston and raises to its uppermost position the piston valve. The admission valve, which is shown closed, closes in this position by means of the valve stem the passage *i* for the exhaust of the compressed air from the air cylinder. At the beginning of the downward motion of the admission valve the compressed air under the air piston can flow out by means of the slot *d* of the carrier pin, while a further exhaust occurs through the passage *i* which is opened by the valve stem. During the downward motion of the admission valve, and the mixing and compressed air valve *b* outside air flows into the space under the air piston *a* through the passage at *m*. The throttling screw *k* is however adjusted so that above the air piston a small partial vacuum is produced which keeps the valve and air piston in balance. The small check valve *l* acts only during the upward motion of the air piston, if the throttling screw *k* begins to brake the motion too strongly. It must be borne in mind that for the upward motion of the air piston and valve, the period of 2.5 piston strokes is available, which is quite a long time. The oil passage *n* brings oil under pressure to the slide valve *b*, while the air piston *a*, and the admission valve stem are lubricated through the opening *o*. The admission valve with its second packing surface *p* acts simultaneously as a gas shut-off valve. The end ring *q*, turned so as to have a certain play, holds the gas passage somewhat closed at the opening of the admission valve and beginning of compressed-air scavenging until the flow energy of the compressed air forces the gas into the cylinder, up to shortly before the dead point. The mixing-air and compressed-air slide valve moves down automatically, together with the admission air valve under the slight braking action of the small partial vacuum produced over the air piston. During the downward motion the compressed air passage is closed by the valve at about one per cent beyond the dead point and the mixing-air passage remains closed by the valve somewhat longer than that even, so that into the cylinder can flow only clean gas which mixes in the compression chamber with the scavenging air. The duration of the pure gas flow, in accordance with the heating value of the gas, can be maintained up to 30 per cent beyond the dead point, whereafter the mixing-air passage is laid open by the slide valve, gas and mixing air are allowed to flow in until the end of the suction stroke in the usual manner. The mixing-air and compressed-air valves then come to rest in their lowest positions while the admission valve alone moves upward into its final initial posi-

tion. Then only the piston valve turned on to the valve spindle opens a smaller annular passage surrounding it, admitting compressed air under the air piston, and permitting it to raise both the piston and the slide valve into their upper positions. For testing the air piston and its slide valve with respect to ease of run (for instance after long standing) two threaded holes are placed at 180 deg. to each other and the openings *s* are used, the piston and slide valve being moved up and down by means of screws. Openings *s* are then closed again by screws *t*. The gas flap valve *u* is actuated from the governor in the usual manner while the mixing flap valve *v* is adjusted by hand. The arrangement efficiently prevents the formation of a mixture in the valve casing and permits it only after the

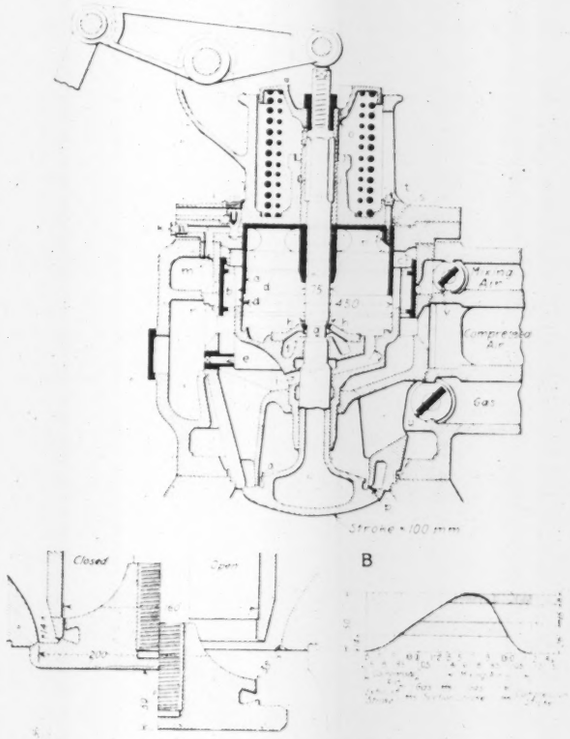


Fig. 3 Gas Engine Admission and Scavenging
A. Gas Engine Admission Valve Gear; B. Admission Valve for Blast Furnace Gas Engine with Gas Having a Heating Value of 700 to 900 W.E. (1260 to 1620 B.t.u.); C. Valve Gear Diagram for the valve shown in B.

passage through the admission valve. This eliminates backfiring in the valve casing and permits the mixing and compression air valve to move in pure air only. If the gas engine is operated without scavenging, the compression air is shut off and the mixing air and compressed air slide valve is automatically pressed to its lower position while the mixing air passage is kept frequently open. The engine is then operated in the usual manner.

The author discusses further the design of admission and gas valves for gases of various heating values, and shows governor diagrams for blast furnace gas driven dynamos running at a constant speed, and for a blast furnace gas driven blower running at variable speed.

Mechanics

Ruptures of Machine Parts (*Brüche an Maschinenteilen*, Kasten. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 1, p. 4, January 2, 1914. 2½ pp., 10 figs. *d*). The great advantage of the electric elevator consists in the fact that it may be arranged so that the car may always be stopped exactly at the level of the floor, which is of importance especially in the handling of freight.

In the button pressure control electric elevators, the correctness of the stoppage of the car depends to a certain extent on the personal equation of the operator. On the other hand, the electric elevator presents certain advantages, and attempts were naturally made to combine the advantages of both types. The evident way to avoid the disadvantages of rope elevators for the delivery of freight was to replace the load post of the hydraulic elevator by a jack screw in the electric elevator. The author could find no data as to the efficiency of the jack screw type, but it appears certain that it is more economical than the hydraulic elevator. In a large plant, tests have shown that the current consumption for a lift of about 4 meters (13.1 ft.) and a load capacity of 1000 kg. (2200 lb.) is, on the average, about 65 watts. In this type of elevator the influence of the connecting elements of the car and driving engine is eliminated, but the influence of the load, brake and the slowing-down path is present in this type also when the elevator has electric lever or press button control. The elevator therefore always has a tendency to pass its stopping level, and injuries to the electrical and mechanical parts are possible. The proposal to install an elastic element between the jack screw spindle and the car has met with objections, but it is remarkable that no attempts have been made to enable the operator to control the brake directly, as it would appear that it is the one way to make the electric elevator as reliable as the hydraulic.

The author discusses and illustrates a case of a rupture in a jack screw elevator which shows that particular care must be given to the connection between the car and the spindle. He shows also several designs of connecting elements.

Refrigeration

Reversible Absorption Machines (*Reversible Absorptionsmaschinen*, E. Altenkirch. *Zeits. für die gesamte Kälte-Industrie*, vol. 21, no. 1, p. 7, serial article, not finished. *d*). Complete exposition of the theory and construction of absorption and resorption refrigerating machines. Preliminary statements have been published before, in a paper presented to the Third International Congress of Refrigeration (Chicago, 1913), and in various publications (cp. *The Journal*, September 1913, p. 1574).

Steam Engineering

Brünler Boiler with Underwater Firing (*Die Unterwasserfeuerung System Brünler*, Jaeger. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 2, p. 13, January 9, 1914. 4 pp., 1 fig. *de*). All steam boiler construction has so far been based on the idea of producing heat on one side of a good heat conductor, placing water or a corresponding liquid on the other side of the conductor and endeavoring to transmit as much of the heat produced as possible through the partition to the steam generating liquid. Of course, large heat losses are unavoidable in this process.

From this point of view the system invented by a German engineer, O. Brünler, is decidedly novel since he generates heat directly under water without any heat conducting element between the source of heat and the steam generating liquid. His process is, to a certain extent, a return to the

principle of the so called "Greek Fire" which was in use about a thousand years ago and the method of working of which is still somewhat of a mystery.

Mr. Brünler built his first boiler some six or seven years ago, but the difficulties encountered have been so numerous that the tests had to be given up. Lately, however, an important boiler has been placed at work in a chemical factory in Germany of the Wesenfeld, Dicke and Co., in Dahl near Langerfeld, where it is used for the evaporation of tungstic soda solution. The steam generated cannot be used yet for other purposes because, under the German police regulations, this boiler does not correspond to the approved boiler standards, and may not be placed in regular operation.

The plant consists of the generator proper in which the flame is produced under the water level, and the collector A with the pipes connected to it, a and a_1. This collector

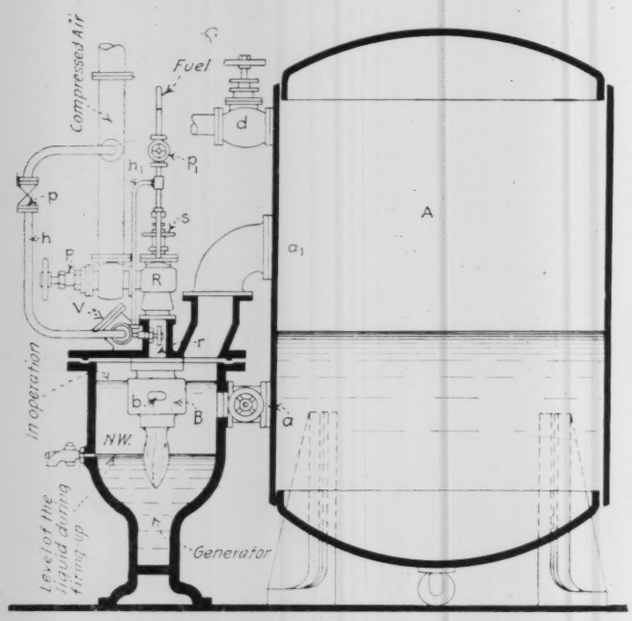


Fig. 4 Brünler Boiler with Underwater Firing

serves for the storage of the liquid from which steam is to be generated as well as a collector of the steam generated and the gases produced in the process of its generation (carbon dioxide and nitrogen). The collector is made of wrought-iron sheets; and the generator in this case of steel casting, which is used because this material resists better the action of tungstic soda solution than would wrought iron.

Tar oil having a heating value of about 9000 WE (16200 B.t.u.) is used as fuel in this case, but producer gas, coke oven gas, or any other gas, can be used with properly designed burners B for each case. The tar oil flows to the burner through a mixing valve R into which is brought laterally the compressed air pipe. The air and fuel admissions are regulated by a governor wheel s. When the firing is started, the valves P and R are closed. After the opening of the valves P and P_1 the tar oil and compressed air pass through auxiliary pipes h and h_1, to the small mixing valve r and from there into the auxiliary vaporizer V. In the latter is located an ignition tube, which when the firing has to be started is brought to a dark glow by means of a torch (to do this, the cover of the vaporizer has to be taken off). The mixture of compressed air and finely atomized tar oil flows through r, is ignited on contact with the ignition tube and in a short time brings it to a bright red glow. There is inserted in the upper opening of the auxiliary vaporizer V a graphite disc which cuts off the ignition tube and forces the gases of combustion to flow through the inner part of the burner B. The latter at b is forked out and forms a hollow cooling space which is in connection with the water level. When the firing is started an adjusting valve at a is kept closed; then so much liquid is let into it from A that the level of the liquid NW is just under the opening of the burner. Through the action of the hot gases of combustion coming from the auxiliary vaporizer V, the upper plate b in the fork of the burner is brought to a red glow in a few minutes, a process which can be observed through a round spy-window in the wall of the generator. When this is so the cover of the vaporizer V is screwed on and the main mixing valve R is adjusted by means of the wheel s after the valve P is opened. The tar oil flowing in is vaporized in the highly heated upper part of the burner B, is ignited at b, and a flame cone is formed at the lower opening of the burner.

After the auxiliary mixing valve r is closed, the valve at a is slowly opened so that the liquid reaches to the upper part of the burner and cools it from outside. As soon as this is done the liquid is brought to violent boiling through direct transmission of heat from the flame cone. The gases of combustion, consisting of carbon dioxide and nitrogen, pass together with the steam generated through the pipe a into the collector A. These gases and steam carry with them large amounts of liquid, the flame acting somewhat like a Mammoth pump so that lively circulation is produced in the collector and generator. The boiling of the liquid in the generator produces a cooling of the cover of the latter so that its external temperature is always below that of the steam.

In addition to that there is an asbestos sheet placed between the burner and the cover so that the hot top of the burner shall not heat the cover too much by conduction. The entire apparatus therefore remains comparatively cool, but if necessary may be covered by heat insulating materials from the outside so as to avoid radiation losses. In no case can the heating of the walls to a glow heat take place, and the worst that may happen is that through lack of water the top of the burner B may come to a glow, perhaps to a white glow, and may even be entirely melted. If this should happen there would be no dangerous results. In the first place the attendant would rapidly observe by the manometer of the collector A that the water level of the latter rapidly falls down, which would indicate that the pressure of the gases in the generator has come down, and would take corresponding steps. In the second place the melting of the burner would produce a closing of the passages, which in its turn would shut off the supply of gas and compressed air, and put out the flame. Should, however, the burner, instead of being melted, develop a side passage for the gases and air, the amount of the flow of gases would be so small that the flame under the action of water would be rapidly extinguished again. The Brünler steam generator, as far as safety from explosion is concerned, is therefore superior to the usual boiler types. A further advantage of this generator is that no boiler scale formation has been observed

even where very poor feedwater and concentrated solutions have been used. When ordinary water is used for feeding the boiler, the favorable result is due to the fact that the carbon dioxide of the gases maintains the carbonates in the water in the form of acid carbonates, $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$ in suspension while the sulphuric salts are, as is known, the only ones which, when the point of saturation is exceeded, fall down in a fine powder. There is another circumstance also which contributes to the same effect: in the generator the boiling of the liquid is so intensive that there can be no stationary layers which contribute to the formation of mineral deposits. (Owing to the violent boiling and eddies, the use of a water level glass in connection with the generator is absolutely useless, and a manometer on the collector *A* takes its place to a certain extent.) The salts of the sulphur formation are, of course, deposited in the collector, but form no rigidly adhering scale. Owing to the fact that the collector is not strongly heated they are there only as a sort of mud. The water level in it is also fairly even and is not subjected to constant oscillations or to continual variations, as in usual boilers. There seems to be a complete suppression of steam and gas bubbles on one hand and water on the other in the generator, and the inventor claims that very little steam is given off in the collector. A little distance below the water level the temperature sinks very little below that corresponding to a boiler temperature for the respective steam pressure, and if these data prove to be correct that would explain why so little scale is formed in the collector. It is, of course, clear that the pressure of the air of combustion must be higher than the steam and gas pressure in the boiler, since otherwise the flame would not be able to develop under the pressure coming from the direction of the water level. There is formed around the flame a zone of superheated steam and superheated gases. The latter, in view of the violent formation of eddies in the generator, must separate from the water so fast that they have to reach the collector 30 to 40 deg. cent. hotter than the latter, and in the collector they produce a drying action on the steam and communicate to the mixture of the gas and steam a higher temperature than corresponds to the temperature of saturated steam as given by tables. Although the test made by Wesenfeld, Dicke and Company confirm this fact, still it requires further proof to confirm the claim of the inventor that the fuel, in this case tar oil with a heating value of 9000 WE (16200 B.t.u.), evaporates more water than corresponds to the usual theory of evaporation. This is probably due to the chemical action of ultra violet rays produced in the flame, kept back by the screening action of water, and conducted away by the metal in calorimeter tests from which the theory of evaporation is deduced. Anyhow, it is his claim that in the present tests 1 lb. of tar oil produces an evaporation of 20 to 21 lb. of water from a solution of tungstic soda, while in one test of 36 hours an evaporation of 24 lb. of water per pound of fuel has been obtained as against the theoretically possible evaporation of 14 lb. The article contains a tentative heat balance as well as a discussion of the possible advantages of this boiler.

THE LOCOMOBILE DRIVEN CENTRAL STATION AT WIBORG IN FINLAND (*Das Lokomobilkraftwerk Wiborg in Finland, Annalen für Gewerbe und Bauwesen*, vol. 74, no. 872/2, p. 33, January 15, 1914. 3 pp., 5 figs. *d.* Practically the same article can be found in *Zeits. für Dampfkessel und Maschinenbetrieb*, vol, 37, no. 4, p. 38, January 23, 1914). The superheated steam locomobile has proved to be nearly as economical in its steam consumption as the steam turbine and lately it has begun to be used for continuous power production in large power plants, especially in Northern Europe. The author describes a very interesting installation of this kind in the city of Wiborg in Finland where three superheated steam compound locomobiles, Wolf type, have been placed to supply power and light to the entire city in connection with a small water power plant. The arrangement is as follows: In the daytime the power is supplied by

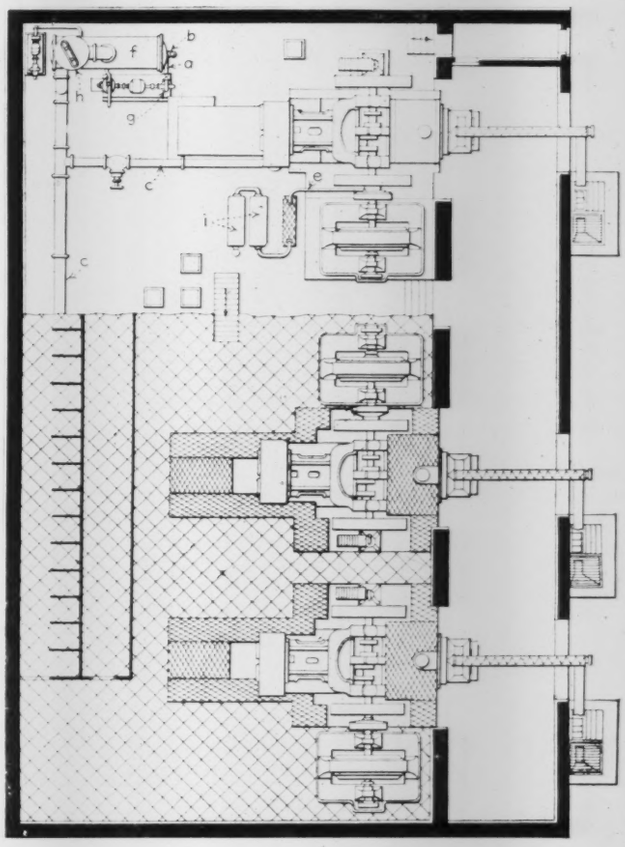


FIG. 5 WIBORG LOCOMOBILE DRIVEN CENTRAL STATION

Piping: *a* supply of circulating water; *b* discharge of circulating water; *c* vacuum piping; *d* boiler water discharge; *e* feedwater suction piping; *f* surface condenser; *g* circulating water pump; *h* steam oil separator; *i* water oil separator.

the hydraulic plant and one of the locomobiles, on which the load varies from 450 to 600 horsepower, that is, it remains continually within the most economical limits of fuel consumption. At dusk the second locomobile is placed in parallel, and in the course of the evening the load of the two locomobiles rapidly rises to about 1200 h.p. so that each locomobile works at its best economic output. In order not to overload the plant a third locomobile is all the time under steam ready to be switched in as soon as necessary. About midnight one of the two working locomobiles can be cut out, the other locomobile together with the water power plant taking care of the remaining load, street lighting and

house lighting. The electrical part of the plant consists of three polyphase generators of the German General Electric Company, 380 kw., power factor 0.8, 3000 volts, 50 cycles, 170 r.p.m.; each generator is directly coupled to a shaft of the corresponding locomobile, the coupling being a flexible band of the Zodel-Voith type, which has an advantage as compared with the absolutely rigid coupling, in that when several machine aggregates are placed in parallel, it prevents dangerous shocks in the generator and tends to damp out hunting. As regards the steam end of the plant, multitubular boilers with withdrawable tubes are used in connection with spiral superheaters, each boiler being provided with separate devices for blowing off steam, for cleaning the boiler pipes and superheater coils. The compound engine is placed on the boiler itself, whereby the constant relation of all the engine parts to one another is secured. The distribution of steam in each of the two cylinders is secured by a simple piston valve with narrow spring packing rings of the R. Wolf type, while the governing is effected by the axle governor connected with the eccentric of the high-pressure piston valve. With due regard to the units being placed in parallel, each aggregate is provided with a regulating device by means of which the speed of rotation may be either raised or lowered within certain limits by a hand wheel acting on the axle regulator. Each boiler has an independent stoking arrangement, the coals being thrown into the loading room under the machine room by means of funnel-shaped openings, and from there taken up to a height of about 5 m. (say 16 ft.) by a screw conveyor which carries them over shutes placed over the firing. Shovel stokers are used for the stoking proper and are driven from the shaft of the locomobile. A part of the space is occupied by the condenser plant which is characterized by the rather novel arrangement, according to which all three units have a central condensation arrangement built by the machine factory of the Balcke Company in Bochum. The exhaust steam flows through pipe *c* which acts as a common piping for all three locomobiles, then through the oil separator for steam *h* and up to the surface condenser *f*. The first water of condensation passing from the steam oil separator, and still containing a large amount of oil, is sucked up by a small centrifugal pump directly connected to a polyphase electric motor. On the other end of the shaft of this motor is a second small centrifugal pump which drives the main water of condensation from the surface condenser *f* through a coke filter to the feedwater tank. The cooling water is brought to the condenser by the piping *a* by means of the cooling water pump *g*. The motor which drives this cooling water pump is connected on its other end to a second centrifugal pump which acts as a vacuum air pump for the condenser. The cooling water leaves the condenser by the piping *b*.

Official tests made at the factory of the builders have shown a fuel consumption of from 0.486 to 0.505 kg. (10.6 to 1.11 lb.) per h.p-hr., and a steam consumption of 4.2, 4.16 and 4.2 kg. (9.24, 9.16 and 9.24 lb.) per h.p-hr., with loads of 556 h.p., 530 h.p. and 525 h.p. respectively, the tests lasting from 3 hours to 4 hours.

TESTS ON THE INFLUENCE OF COMPRESSION AND SURFACES THROUGH WHICH IS EFFECTED THE HEAT EXCHANGE IN STEAM CYLINDERS, ON THE WORKING PROCESS OF A SINGLE CYLINDER ENGINE (*Versuche über den Einfluss der Kompression und der Oberflächen, an denen sich der Wärmeaustausch im Dampfzylinder vollzieht, auf den Arbeitsvorgang einer Einzylinder-Maschine*, E. Heinrich. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, nos. 1 and 2, pp. 15 and 58, January 3 and 10, 1914. 12 pp., 26 figs. *etA*). The article presents advance information of a series of tests made in the laboratory of Prof. C. Von Bach.

They differ from similar experiments previously made in that an arrangement was devised by which the areas through which the heat exchange took place could be varied. Both jacket and cover heating were used while in some cases no heating was used at all. The compression varied from 0 to 50 per cent as determined by diagrams taken from the exhaust valve. Steam consumption was determined in two ways: first, by the determining of the amount of steam brought in, and next by measuring the amount of water of condensation. The tests were made in the special laboratory of Professor von Bach, which afforded particular facilities for this kind of work. The boiler *a* (Fig. 6A) a small unit of the Prégardien type, with inclined grate and heating area of 100 qm. (1070 sq. ft.) generates what is called "heating steam," which in its turn produces the working steam. The steam boiler *b*, with a heating surface of 200 qm. (2140 sq. ft.) consists of a group of vertical pipes, its heating surface serving partly for the production and partly for the drying of the working steam. The advantage of this arrangement consists in a precision of measurement of the feedwater otherwise unattainable, especially in short tests, since in this indirectly heated boiler, the water level is nearly absolutely stationary. The steam engine can be used either as a single cylinder, or as a compound engine, or finally as a triple expansion engine with four cylinders, and can be used either with saturated steam or with steam superheated up to 250 deg. cent. (482 deg. fahr.) with a maximum output of about 200 e.h.p. In this case it was used as a single cylinder engine. This engine possesses an important advantage for the present test, in that its compression may be adjusted by hand from 0 to 50 per cent while the engine is in operation. In addition to this, the crank is also adjustable so that the stroke may be reduced from normal dimensions downwards to practically any desired amount, thus permitting it to work with variable clearances. The admission can be varied from 0 to 60 per cent, the speed from 20 to 130 r.p.m., both being adjustable by hand while the engine is running. The cylinder has a stroke of 761.5 mm. with 250.8 mm. bore. Both the jacket and cover may be either heated by steam or left without such heat. Special arrangements have been provided for the thermal elements to measure the temperature of the walls of the cylinder and cover. The plant is provided with jet and surface condensers, a wet pump and a pump for the cooling water being driven directly from the engine shafting. In order to increase artificially the area of the clearance space, the stroke was reduced from 761.5 mm. to 701.9 mm. and the space left free in this way was filled up either fully or partly with iron plates and perforated iron sheets, the total weight of which was so selected that in all cases there should be equal clearance on both sides of the piston: approximately 8.7 per cent. In this manner the area of the clearance space was divided into four stages, rising from approximately 0.404 qm. to 0.789 qm. (4.32 to 8.44 sq. ft.). Fig. B shows the arrangement of these additional elements and indicates that they are formed out of pieces of iron which are only slightly connected with

the other cylinder walls by means of supports having a very limited cross-section. In considering the number of these auxiliary areas in the heat exchange the masses of iron of which they are formed must also be taken into consideration. If O is the surface of one of such "free iron weights," independent of the walls, G is its weight and γ is the specific weight of iron, then

$$\delta = \frac{G}{O\gamma}$$

is the average thickness of O, i.e., the average depth which is available for the penetration of heat waves into the iron. In this case the value of δ is the same for all stages; viz., 0.6 mm. (0.024 in.)

In all tests, the admission pressure of the steam was maintained at 7.2 atmospheres gage; the pressure in the exhaust valve chest at about 0.15 atmospheres absolute, the admission at about 18 per cent and the speed at 92.5 r.p.m. The compression was varied in four stages, viz., 1, 12, 25 and 50 per cent and in order to maintain all other conditions equal, it was found advisable to vary the compression without interrupting the operation of the engine. Therefore in each case four tests of from two to three hours each were carried out with intervals of about one to two hours. Figs. C and D show the steam consumption per i.h.p-hr., with and without heating, as functions of the degree of compression. Other figures give the same steam consumption as a function of the compression end pressure as well as the steam consumption for the different degrees of compression as a function of the areas. In Figs. C and D each test is represented by three points, the upper point corresponding to the value derived from the measurement of the feedwater: the lower point, the value derived from measurement of the water of condensation and the inner line the arithmetical means of the two. Figs. C and D show that, under the conditions maintained during the test, the steam consumption was at its minimum at degrees of compression between 10 and 25 per cent. In the test where the lower steam consumption was obtained, the most favorable degree of compression approaches the upper limit, while in the test showing a higher steam consumption (without heating, large areas), the lower limit is approached. It appears from the other figures that the most favorable steam consumption in all the tests was obtained with the same final compression pressure, and was found at between 1 and 1.5 atmospheres absolute, but the curves obtained are so flat that it appears that deviations from the most favorable degree of compression or most favorable final compression pressure do not produce an economically important influence on the steam consumption. The most favorable steam consumption is approximately obtained at the pressure at which the final temperature of compression is equal to the temperature of the walls, but it appears that the heat exchange between the compression steam and the wall does not absolutely determine the influence of the degree of compression on the steam consumption. Further, the initial condensation, at least within the limits of degrees of compression which are actually used in practical operation, is practically independent of the degrees of compression which materially affect only the heat losses due to the clearances.

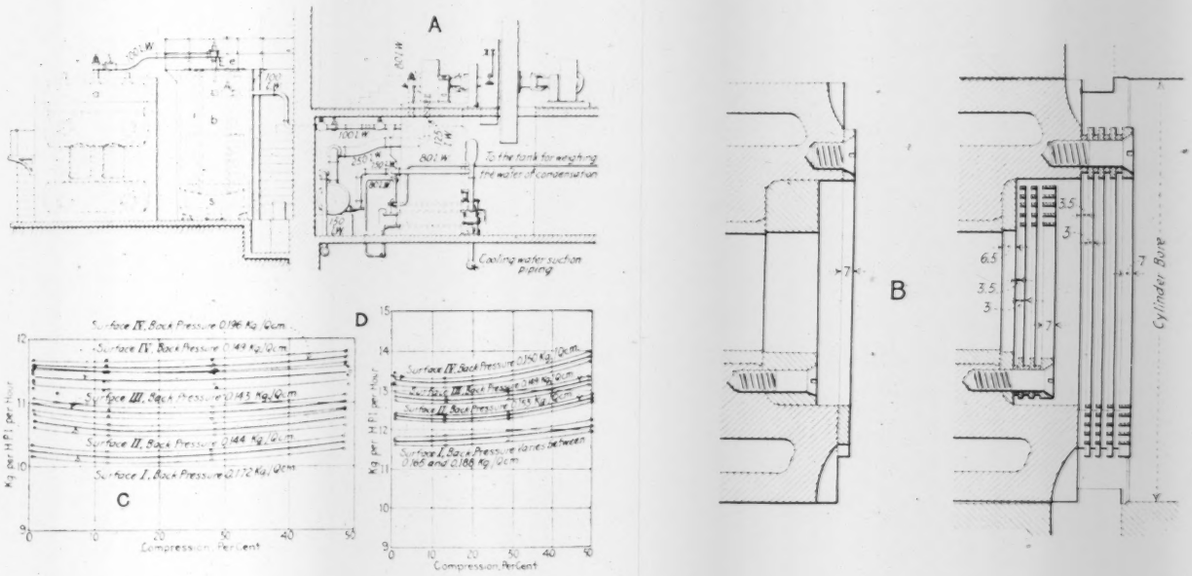


Fig. 6 Plant and Data of Tests on Heat Exchange in Steam Cylinders

The author made a purely analytical calculation of the shapes of the curves of steam consumption in connection with the degrees of compression based on the above statement under the assumption of different efficiencies, and obtained for efficiencies used in the test, curves which were in every respect similar to those obtained from actual tests. It appears therefore that the shape of the curves is determined by the quality. The most favorable degree of compression is reduced only when the quality becomes less, while higher degrees of compression have their most favorable values for higher qualities and tend to become unfavorable when the qualities become less. In engines of this kind (i.e. working with saturated steam and condensation), when the quality is known and the admission remains constant, an idea may be gained by simple calculation, sufficiently exact for practical purposes, as to the relation between the degree of compression, as well as the most favorable degree of compression.

The action of artificial surfaces, Fig. B, which provide an

average depth of wall material of about 0.6 mm. (0.023 in.) for the oscillation of the heat waves appears to be proportional to their dimensions both with respect to steam consumption and to initial condensation. Owing to the slight depth of oscillation which they offer to the motion of the heat in the wall, the action of these surfaces is slighter than that of the surfaces of the normal walls, in which latter is provided a possibility of unlimited permission of heat oscillation. The action of the surfaces for a wall thickness below a certain limit appears to be a function of that thickness. In the present case, in round numbers, it appears that the action of the additional surfaces is to the action of the original surfaces with respect to steam consumption, approximately as 1 : 3; with respect to initial condensation as 1 : 2. Calorimetric investigation shows the generally known differences in the processes of heat exchange with and without heating, the larger initial condensation, the smaller supply of heat during the period of expansion without heat as compared with what happens with the heating of the steam jacket. The other parts of this investigation will be reported after the appearance of the complete publication in the *Mitteilungen über Forschungsarbeiten.*

Loss of Heat by Locomotive Boilers through Cooling (*O potere teploty paravoznymi kotlami ot ocklajdeniya,* M. V. Gololobov. *Bulletin of the Permanent Committee of Advisory Conferences of Officers in Charge of Various Branches of Service on Russian Railroads* (in Russian), vol. 12, no. 12, p. 1013, December 1913 serial article, not finished). The amount of heat lost by locomotive boilers through surface cooling cannot be strictly determined from theoretical and physical data. The boiler presents a combination of several geometric bodies, each of considerable dimensions. It consists of a cylinder which ends at the rear by a parallelopiped with a round or flat top. On the cylindrical part there is a steam dome in front of which is located the smokestack and often the lantern. The rear part of the boiler (jacket) is often partly inside the cab. Finally the lower part of the furnace is located between the frames and has no lagging. The part of the outside shell of the firebox inside the cab on some railroads is not provided with lagging so that in the winter the men in the cab would not feel the cold. Even in the simplest case, when the boiler of a *locomotive at rest* is in stationary air, the elements of its surface will not be in entirely uniform conditions owing to the large dimensions of the boiler parts. The air particles heated by contact with the lower elements of the surface form rising currents, the temperatures and velocities of which increase gradually from bottom to top as long as the air remains in contact with the surfaces at higher temperature. The phenomenon will therefore be dissimilar for the same cylinder, in accordance as its axis is horizontal or vertical, and will be further dissimilar for flat, vertical or horizontal walls of the same surface. In physics, the action of the surfaces of large dimensions is but little investigated, although Ser in his *Cours de physique industrielle,* Vol. 1, Pp. 137-138, gives a formula for a sphere, vertical surfaces and cylinders with vertical and horizontal axes.

When the locomotive is in motion, the phenomenon is still more complicated by the fact that air currents flow along parts of the boiler following complicated trajectories which depend not only on the shape of the boiler, but also on its velocity, while behind the smokestack, steam dome and cab there are dead spaces, some of which screen one another. The surfaces within these dead spaces, or screened otherwise, will lose less heat since the air there is warmer through being subjected to less intensive exchange. A lateral wind complicates the situation still more, as on the whole, it would be expected to increase the cooling by blowing out the air from the dead spaces and reducing the screening effects. It appears thus that the problem of the cooling of a locomotive boiler in motion is a very complicated one.

From what has been stated above, three important conclusions may be drawn: First, the coefficient of cooling, i.e. the amount of heat lost per hour per square meter of boiler surface for the difference of temperature of 1 deg. cent., as determined from experiments on the cooling of boilers of small dimensions, is not fully applicable to locomotive boilers for which the coefficient must be determined by tests on locomotive boilers themselves. Second, if the coefficient of cooling be expressed by the formula $k = a + b\sqrt{v}$, where v is the velocity of motion, k for a stationary locomotive cannot be considered equal to k when $v = o$ (for instance to a), since k must be different and generally larger than a, owing to the fact that the air is never stationary when in contact with the walls of a stationary boiler. Third, the coefficient of the heat loss from the surface of a boiler is a variable quantity, so that one can consider only its average magnitudes not only for the entire boiler but for parts of it, uniformly screened and approximately under uniform conditions.

Owing to the complications introduced by these features, general methods of determining heat losses of a boiler in motion are of necessity extremely simple and rough. The inequality of the coefficient of cooling for the various parts of the boiler and its functional relation to the speed of motion are generally neglected, and sufficient attention is not paid to the selection of a proper numerical value for the coefficient of cooling.

The author proposes to review the experiments previously made for the determination of the coefficient of cooling of the boiler surfaces in accordance with the formula $k = a + b\sqrt{v}$ as the derivation of a most correct method of solving the problem of the cooling of the boiler with due regard to the various method of boiler lagging.

Forty-Third General Meeting of the Delegates and Engineers of the International Association of Boiler Inspection Societies (*Die 43. Delegierten- und Ingenieur-Versammlung des Internationalen Verbandes der Dampfkessel-Überwachungs-Vereine. Glückauf,* vol. 50, no. 3, p. 96, 4 pp. *g*). Only sections of possible interest to the American engineers are here reported. (*A*) *Report by Professor Blacher, of Riga, on Harmful Ingredients Contained in, or Added to, Boiler Feedwater, and on the Influence of the Working Pressure on the Action of the Said Ingredients.* The presence of carbon dioxide in the boiler feedwater cannot be considered objectionable as a rule, but where the process of corrosion of the boiler sheets has already started, it may accelerate it. It can, however, be easily removed by caustic soda. Air must be considered as a harmful agent, since the protective action of oxygen in boiler practice has been neither observed nor proved. The air in the presence of chlorides and under certain conditions causes dangerous spot corrosion, and since it is due to the action of the oxygen of the air mechanically carried into the boiler with the feedwater, it is advisable to take care to admit

as little as possible. It is very desirable to admit the feedwater either into the steam space or closely below the water level, so as to permit the air to escape into the steam. If there is a large amount of chlorides present in the water, it appears advisable to reject such water entirely, but if not, it is well to observe the inside of the boiler very carefully, and as soon as signs of corrosion appear, to install zinc plates in metallic connection with the boiler shell, taking care, however, to see that as little as possible of air is allowed to enter, since otherwise the oxygen will in a very short time destroy the zinc. As regards the *organic constituents*, Reischle, of Munich, discusses particularly the action of various tar, asphalt and graphite paints and mentions the Brun process, widely used in Switzerland, which consists in the addition to the boiler water of some linseed oil. On the whole, he comes to the following conclusions with respect to the use of means for preventing scale. They prevent more or less formation of scale but cannot be considered as a certain method of protection, with the exception perhaps of the above mentioned Brun process; they produce solution of old scale only occasionally, but usually make it brittle so that it either breaks off of itself or can be more easily removed. Sometimes their application may lead to overheating and injurious results to the boiler plates, especially the firebox plates, and finally they can produce clogging of the water level glass and blow-off cocks.

(*B*) *Report on the Causes of Bulging of Tubes in Water-tube Boilers even with a Small Deposit of Scale: can the influence of the shape of the firebox and adjoining heat passages be established in this connection?* The report of Chief Engineer Czernek, of Frankfort (Oder) states that formerly ruptures of water tubes were generally ascribed to poorly welded seams, but when seamless pipes came to be used, the number of ruptures did not decrease to the expected amount because, at the same time, the boilers were subjected to higher stresses owing to the introduction of superheats, and this became still more evident when, with the introduction of efficient chain grates and other systems of mechanical stoking, the temperatures in the firebox became considerably higher than those met with in hand fired plants. The places where ruptures of tubes frequently occurred were the first and second row of tubes, but nearly always in the part of the boiler surface subjected to heat radiation. The material used in the compilation of the report shows with nearly perfect uniformity that the causes of the rupture of tubes were unsuitable feedwater in connection with an unsuitable design of the firing space. If, for example, the firing space for the fuel in question is not built wide enough so that there is a second burning zone, due to eddy formation of gases in the neighborhood of the tubes owing to sharp changes of direction, there is always produced an over heating of the pipe walls. If at the same time unsuitable water is used, injury to the pipes becomes inevitable. On the other hand, where the firing space is properly designed and good feedwater, consisting mainly of oil-free water of condensation, is used, the pipes will remain in good condition after many years of strenuous work. Therefore, for the prevention of injury to the pipes, the following rules should be observed. Feedwater containing oil or organic substances should be avoided while the mineral substances should be removed by chemical means. The water must be brought to a high temperature in preheaters and the velocity of flow must be low. Nevertheless, if scale formation is observed, the boiler must be cleaned at short intervals, and especially after having been cold for a long time. Complete combustion of the fuel must be striven for; even with fuels rich in gases, the combustion must be completed in the firebox. To prevent the formation of long drawn out flame, additional air may be brought in at an angle to the direction of the flame. The fuel gases, when they leave the combustion chamber, must pass very close to the tubes and sharp changes of direction and all air supply at that point must be avoided.

Technical and Economic Experiences in Steam Turbine Operation (*Technische und wirtschaftliche Erfahrungen im Dampfturbinenbetrieb,* Professor Josse and K. Hoefer. *Zeits. für das gesamte Turbinenwesen,* vol. 10, nos. 33, 34, 35, 36, November 30, December 10, 20, 30, 1913. *sA.* Conclusion of abstract begun in *The Journal,* February, 1914, p. 037). The article gives complete data, in the form of tables and curves, of steam consumption of turbines per kilowatt-hour. It points out that in various plants the experience has been that the steam consumption increases up to about 5 per cent during the first few years after the installation of the plant, although it worked under the same conditions of operation as before; partial renewal of the blading did not reduce the steam consumption to its initial level. The cause of this phenomenon could not be established. A very important question is that of steam consumption at partial load, since most of the time the power plant does not operate under its full load. The author quotes data for the steam consumption of various turbines at one-quarter, three-quarter and one-half load, and it appears that the large turbines are more economical at partial load than are the smaller turbines. In general, the turbines with a Curtis wheel appear to have a smaller specific increase of steam consumption at partial load than turbines not provided with such a wheel, due probably to the fact that in the first case, at partial load, some nozzles may be closed. It should be noted further that in some cases the steam consumption is lower at partial load than at full load: e.g., at three-quarter load it is 0.992 of that at full load. It appears that in this case the turbine has really been designed not for full load but for load somewhat below it, which would be correct since most of the time the turbine works not at full load but at partial load, and its design for the latter would therefore insure the most economical steam consumption. In addition, the vacuum in the condenser, owing to the small volume of steam at partial load, is improved, which in itself is favorable to the reduction of steam consumption. As regards heat consumption and thermal efficiency of turbine installation, it appears that, although single values obtained in different places differ materially from one another, with the increase of output of the plant there is a reduction in the heat consumption and an improvement in the thermal efficiency. The heat consumption varies from 10,000 WE. (39,700 B.t.u.) per kw-hr. in small plants to about 7200 WE. (34,580 B.t.u.) per kw-hr. in large plants while the thermal efficiency rises from 8.5 to 12 per cent. This is due mainly to the fact that in large turbines there is a small steam consumption. Further, in large installations the boiler and steam piping losses are also smaller, and that in the design of large plants, more attention is paid to, and more efficient devices are provided for, the best utilization of the heat produced. The thermal efficiency of various plants varies within wide limits, viz. from

5.73 to 13 per cent, and it appears that the time when the plant was put up has no influence on the heat consumption. Next to the steam consumption of the power plant, the first cost has the greatest influence on the economical results. The author gives exhaustive data on this matter in the form of details and curves from which it appears that the cost per kilowatt decreases with the increase of output from approximately 180 Marks ($43.20) per kw. for small outputs to about 70 Marks per kw. ($16.80) for outputs of about 6000 kw.

TESTS OF A STEAM WATER HEATER IN COUNTERFLOW AND PARALLEL FLOW (*Versuche an einem Dampf-Wasserwärmer im Gegen- und Gleichstrom*, A. Gramberg. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 5, p. 170. January 31, 1914. 8 pp., 13 figs. *e*). The article reports a series of tests on a water heater used in the machine laboratory of the Danzig Technical High School. It is built in such a manner that it can be used with both parallel flow and counterflow. The heater (Fig. 7A) consists chiefly of a copper heating serpentine coil enclosed in a jacket, the valve arrangement being such that while steam is admitted into the coil, water is at the same time admitted into the space surrounding it and by no error or carelessness can steam be admitted alone. During the test, these valves have been taken out in order to make the cross section enentirely free. The main dimensions of the coil have been determined by careful measurements of the external dimensions and by weighing as follows:

Length of coil, m. ft.	4.22	13.83
Diameter, outer, mm. in	16.5	0.64
Diameter, inner, mm. in	14.1	0.54
Heating surface, outer, qm./sq. ft.	0.217	2.32
Heating surface, inner, qm./sq. ft.	0.185	1.98

The effectual external heating surface of the coil was assumed to be equal to 0.217 qm. (2.32 sq. ft.).

Fig. B shows how the heater is installed: The water may come in either through valve 1 from the city piping, or, if a particularly uniform pressure is required, through valve 2 from a special storage tank, and can be sent through the heater either from the top bottomwards or from the bottom upwards. In the first case, valves 3 and 5 are open and 4 and 6 are closed; in the second case, the reverse is done. The steam comes in in all cases from above and after passing through the water separator, is brought to the pressure at which it is to be introduced in the water heater. The water of condensation flows from the coil downward at *D*. When the water flows from the bottom upward, the heater works on the countercurrent principle; otherwise in parallel flow. This water heater has been used in the machine laboratory for establishing the conceptions of heat of liquid, heat contents of steam, the phenomenon of superheating of same at throttling; great losses of pressure in strongly cooled pipes and similar phenomena. All the important magnitudes may be measured. The water runs usually out at *W* through the funnel into the sink, but may be weighed by deflecting the funnel pipe. Two thermometers, t_1 and t_2, show the temperature of the incoming and outgoing water. The amount of steam may be determined by weighing the water of condensation which flows out at *D* and may be collected in a bucket. The temperature of the outgoing water of condensation is indicated by the thermometer t_3.

In April 1912, the author performed a series of tests described below, the purpose being to see the behavior of the heater at a given steam pressure, at a given temperature of outgoing heated water, at a given volume of water and finally at highest output, this highest output being characterized by the fact that the steam is put through in such

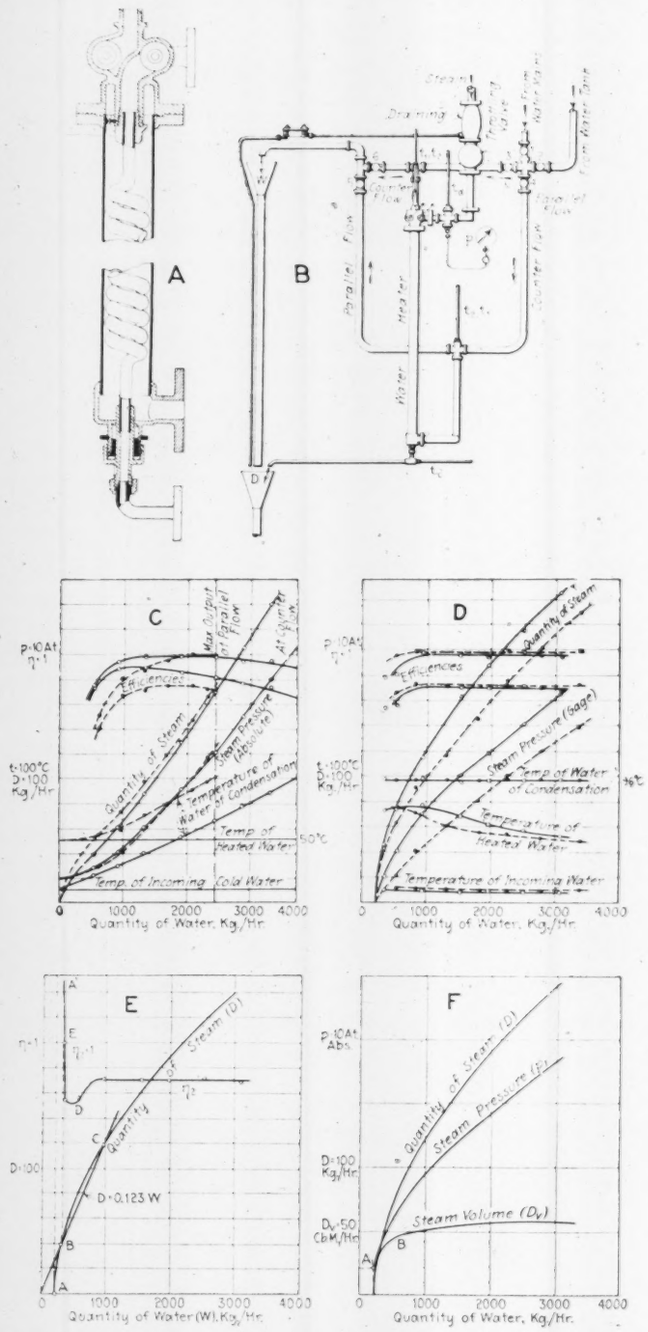


FIG. 7 PLANT AND DATA OF TESTS ON STEAM HEATED WATER HEATER PARALLEL FLOW AND COUNTERFLOW

a manner as to bring the outgoing water of condensation near the boiling temperature.

Series 1: The volume of water was maintained constantly while its temperature, and therefore the exchange of heat, is varied. This was done by varying the steam pressure in

the heater. At moderate pressure, the steam does not penetrate far into the coil; it comes to a certain part of the coil only, while the rest of it remains filled with air, through which, along the walls of the coil, flows the water of condensation so that the pressure in the entire lower part of the coil is equal to one atmosphere. With increasing steam pressure, the steam penetrates farther and farther into the coil as shown by the rise of temperature of condensation due to the fact that the water of condensation, flowing through a shorter piece of the coil, has less chance to cool down below 100 deg. cent. (212 deg. fahr.). When the steam pressure rises, the amount of condensation increases as well as the temperature of the water of condensation. The steam pressures which the heater requires, due to the amounts of heat given up to the water, are quite considerable, and in the present series of tests, have gone up to 5 atmospheres, but with higher steam pressures, the steam breaks through without condensing. The temperature of the water condensation approaches 100 deg. cent. (212 deg. fahr.) and at still higher steam pressure, the entire steam is not condensed and part of it comes out from W. This means steam losses and a reduction of efficiency, and the highest output appears to be obtained when the temperature of the water of condensation is 100 deg. cent. (212 deg. fahr.). This maximum output is higher for the countercurrent arrangement than for parallel flow. A certain amount of water in the countercurrent arrangement is heated up to 69 deg. cent. (156.2 deg. fahr.) while with parallel flow, steam breaks through when the same amount of water is heated only up to 56.5 deg. cent. (133.7 deg. fahr.). The water circulation is therefore correspondingly smaller in the latter case. The efficiency of the countercurrent arrangement is also higher while the temperatures of the water of condensation which represent the heat losses are considerably higher at parallel flow than at counterflow.

Series 2: Behavior of the Apparatus when the Temperature of the Water is maintained at 50 Deg. Cent. (122 Deg. Fahr.). The amount of water is variable and the steam pressure is adjusted by the throttling valve in such a way that the water flowing toward the heater has the desired temperature. The results of the test are repeated in Fig. C, where the curves for the countercurrent arrangement are drawn in full lines and those for the parallel flow in dotted lines. In order to heat larger amounts of water, higher steam pressures are used (up to 10 atmospheres in the present series of tests) and the greater exchange of heat with increase of water means always that larger parts of the coil are filled with steam until finally the entire coil is filled with steam, when the temperature of water of condensation rises to 100 deg. cent. (212 deg. fahr.) and the point of highest output is reached. Comparison shows that for this case, the countercurrent arrangement is always superior to that with parallel flow. This difference in favor of countercurrent flow is especially noticeable at the highest output. At parallel flow in the present apparatus only 2450 kg. (5390 lb.) per hour could be heated up to the standard temperature, while with countercurrent and a higher steam pressure up to 3800 kg. (8360 lb.) per hour would be heated. As regards the shape of the curves, it may be noticed that the temperatures of condensation in one case converge toward the initial temperature of 11 deg. cent. (58.8 deg. fahr.), while with parallel flow they tend to converge toward the outflow temperature of 50 deg. cent. (122 deg. fahr.). The efficiencies are less favorable for small outputs because with uniform temperature of water, the heat losses are constant, and therefore affect a small output more than a large.

Series 3: Behavior with Definite Steam Pressure. When the steam pressure available is maintained at a constant level, say five atmospheres, but different amounts of water are taken out of the heater, the process occurred as represented in series of curves shown in the original article. When the amount of water taken out decreases, its temperature rises as well as the temperature of the water of condensation, flowing out of the apparatus, but the amount of heat exchange and steam introduced decreases. The water flowing through the heater may be reduced until the temperature of the water of condensation rises to 100 deg. cent. (212 deg. fahr.) and then the water reaches the highest temperature which the heater can produce, viz., a little over 50 deg. cent. (122 deg. fahr.) with parallel flow and approximately 70 deg. cent. (158 deg. fahr.) with counterflow.

Series 4: Highest Output of the Apparatus. The highest output of the apparatus is reached when the water of condensation leaves it with a temperature of 100 deg. cent. (212 deg. fahr.) and the steam is therefore just about to break through. For purposes of measurement one has to avoid this highest output, since at 100 deg. cent., notwithstanding careful lagging of the condensation bucket, considerable heat losses take place. For test purposes, therefore, the highest output is assumed to occur when the water of condensation has a temperature between 95 and 97 deg. cent. (203 to 206.6 deg. fahr.). At its highest output (compare Fig. D) the heater can heat the water to a temperature in inverse proportion to the amount of water flowing through it. The efficiencies for equal temperatures of the water of condensation are of course equal and appear to be less attractive for countercurrent flow than for parallel flow. With constantly decreasing amount of flow, the curves of efficiency assume a peculiar formation which, however, holds only for countercurrent flow. The curves of the steam volume and steam pressure in Fig. D converge toward the same point which appears to lie at a water output of about 150 kg. (330 lb.) per hour. The lower part of these curves cannot be obtained, however, since at the limited output of water (150 kg. or 330 lb. per hour) and at zero volume of steam, the water cannot be heated any more up to 75 deg. cent. (167 deg. fahr.), neither will the water of condensation leave the apparatus with a temperature of 96 deg. cent. (204.8 deg. fahr.). The efficiency curves will therefore asymptotically approach the line AA' in Fig. E or the efficiency must become equal to one previous to that. This happens at the point where the curve for the steam volume intersects with the straight line expressed by the equation $D = 0.123W$. From the rise of temperature of water by about 65 deg. cent. (149 deg. fahr.) and latent heat of steam as well as the consideration of the temperature of the water of condensation being 96 deg. cent. (204.8 deg. fahr.), it may be determined that for D equal to $0.123W$, the efficiency η_t is equal to 1. From the point of intersection B is determined, further, the point E to the left of which the temperature of water of condensation of 96 deg. cent. (204.8 deg. fahr.) can no more be secured. The curve of efficiencies η_t appears therefore to have the course shown in Fig. E, which indicates the reduction of temperature of water for outputs of less than 1000 kg. (2200 lb.) per hour. From the date indicated in Fig. D, some further

calculations may be made. From the weight of steam and the steam pressure, the steam volume entering into the heater can be calculated. This is shown in Fig. F, where it appears that at all pressures approximately 55 cbm. (say 1940 cu. ft.) per hour flow into the heater, and since the free width of the coil is 42.1 mm. this indicates a steam velocity of about 100 mm. (328 ft.) per second. This velocity is approximately equal for all steam pressures, but at the left hand of the diagram must approach zero, since under the above assumptions the pressure of the steam at the outlet of the coil has to be equal to atmospheric pressure. (It has been mentioned that the steam valve has been taken out of the water heater and that there were therefore no contractions.) The appearance of this curve is characteristic for the entire phenomenon. For flow without resistance, the velocity remains uniform up to a certain critical pressure ratio (entering flow pressure equals 1.8 of the back pressure and the velocity falls only at similar entering pressures). For flow with resistance in long piping or in steam turbines, the entering velocity remains constant up to a certain larger pressure ratio. In the present case, the reduction of pressure is not readily recognized and the critical pressure ratio may be estimated at approximately 3, corresponding to *B* in Fig. F. The velocity of inflow, although it could not be determined with absolute exactness on account of the uncertainty of temperature of superheat, is still around 100 m. (328 ft.) per sec. It remains therefore substantially below the velocity of sound in steam which at the gage pressures used in this case is somewhere between 460 and 490 m. per second (say 1500 to 1600 ft.). The velocity of sound is therefore not reached by far. The author investigates also the process of heat exchange in pipes and establishes the fact that with a large steam pressure, the pressure losses are considerable.

Strength of Materials and Materials of Construction

Application of Polarized Light to Problems of Applied Mechanics Dealing with Distribution of Stresses (*Les application de la lumière polarisée aux problèmes de la Distribution de l'effort en mécanique appliquée*, E. G. Coker, *Revue générale des Sciences*, vol. 24, no. 24, p. 918, December 30, 1913, 9 pp., 15 figs. etA). In the section "Engineering Societies" are mentioned the Cantor lectures of Prof. E. G. Coker, of London. The present article by the same author presents with considerable detail another method of determining the distribution of stresses in a body by means of polarized light. When a transparent body, such as glass, is subjected to strains, it acquires a double refraction. A sheaf of beams of light, the transversal vibration of which are in the same direction, is broken up into two components, one of which vibrates in the direction of the main maximum stress and the other in the direction of the main minimum stress. If, for example, the case is considered of a rectangular plate (Fig. 8A) subjected to the tensile stresses p and q, at right angles to one another, the state of tension through a plane section which passes through the point O of the plate may be represented by a vector of an ellipse in which the major axis OA is represented by p and the minor axis OB is represented by q. If the plane of vibration of the rays of light is COC', the effect of the system of stresses in the matter is expressed by the division of the rays of light into two components, one of which vibrates in the direction of OA and the other in the direction of OB. The two sheaves of rays do not travel through the plate at the same speed, and although all along the plate they are in phase with one another, they are not so at leaving the plate, and this difference of phase is maintained later on during their motion through the air. Therefore, if one interposes a prism or another device which has the power of selecting the component of each vibration with respect to a given plane, the influence of interference which produces a color sensation may be observed, the latter being particularly clear if the plane selected is at right angles to the plane COC'.

Fig. B gives a diagram of the apparatus used. Glass is not a convenient substance for this kind of test owing to its brittleness, but other transparent substances may be used instead, such as nitro-cellulose products which are consider-

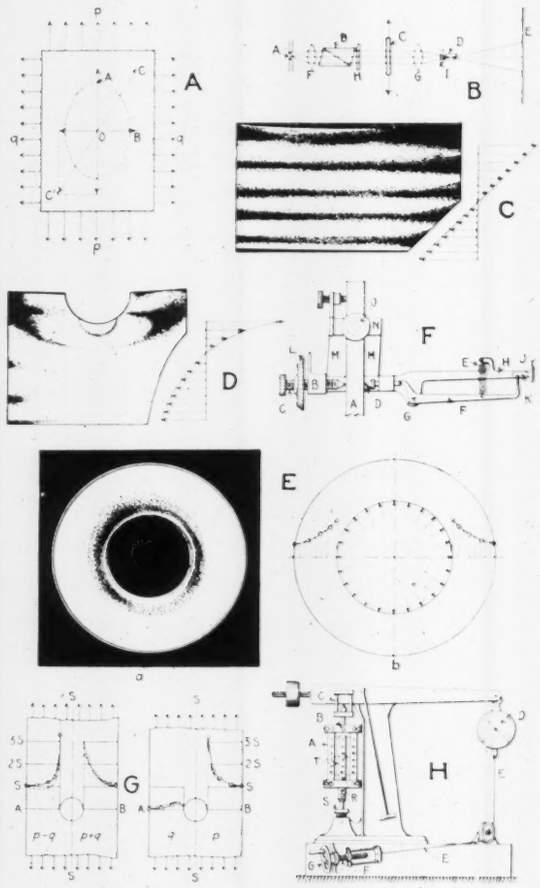


Fig. 8 Determination of Distribution of Stresses by the Polarized Light Method

ably more ductile. The author used a substance called xylonite. If a plate of such substance is placed in the optical apparatus in such a way that when the plate is not subjected to stress, no light is transmitted, a moderate tension produces a white-gray color; as the tension increases, the color passes by invisible gradations to lemon, yellow, purple, red, and finally a clearly defined blue. If the stress is increased further, the scale of coloration is repeated for practically each stage of stresses. In this way a scale of easily recognizable colorations is obtained showing the intensity of the strains in substances. For example, in single tension and compression, the relative lag of light rays which produces the color effect is proportional to the stress and

thickness of the plate; in this case the magnitude of the stress is determined by the appearance of the color bands, the fact that tension or compression produce similar effects if the substance can freely vary in thickness being borne in mind. If a transparent beam is subjected to a uniform moment of bending, a system of color bands is obtained, distributed as shown in Fig. C, and the distribution of stresses across the section can be determined as shown in the diagram at the right hand of the figure. One can see that the stress varies uniformly from the maximum compression on the inner surface to *O* at the center. There it changes sign and uniformly increases up to a maximum tension in the upper part of the beam exactly as in a metal beam subjected to the same kind of load. This is, by the way, one of the cases where the results of optical investigation can be compared not only with the mechanical measurements of strains but also with the theory of distribution of stresses in materials, and it is found that the values experimentally determined for transparent substances agree very well with the exact theory and the measurements of actual strains. One may, therefore, rest assured that in complicated cases, the stresses in a transparent model are the same as in metal elements. The author, as an example, considers the case of a notched beam, as shown in Fig. D, where optical investigation shows, as one might expect, that the influence of the notch is to increase considerably the stress in the substance. The distribution of stresses is now much more complicated than in a simple beam. The neutral axis is displaced toward the notch while the color effects show that the maximum stress is at least twice as large as in a beam without the notch. The color bands really are quantitative pictures of differences of principal stresses at each point, and, from this notion, several applications may be attempted in the field of mechanical engineering. Some of the most interesting of these applications are met with in investigation of curved bodies, such, for example, as pipes transmitting fluids under pressure. The action of water or another fluid may be imitated by applying to the pipe a uniformly distributed pressure by means of a conical mandrel, so that the pressure should be distributed as shown in Fig. *E*a which produces in the beam a perfectly symmetrical distribution of stresses. In this case, the color bands show that there is a large stress at the inner surface which diminishes at first rapidly and then gradually, towards the external surface. There is therefore a strain of radial compression accompanied by circumferential tension and the optical effects at that point are proportional to the algebraic difference of their intensities (in this case to their numerical sum). In a thick cylinder of the same proportions, the radial stress is not great, and its intensity may be determined independently, but their combined effect has been measured (see *E*b). The application of a fluid pressure, measurable at the cylindrical surface of a ring in such a manner that no essential part of it might escape observation, is also an interesting mechanical problem, solved by an assistant of the author in the following ingenious manner: A little pump, the piston of which is actuated by a screw, forces oil at the desired pressure into an annular space between two metal discs, riveted together in the center, and the fluid is sealed in by a retaining rim which prevents its losses. This rim projects slightly beyond the periphery of the disc and carries on it a transparent object submitted to the stress so that all of its parts are visible for the purpose of measurement. The same arrangement may be applied to the case of the thick pipe subjected to external pressure such as happens for example in boiler tubes. In a rim that is subjected to an extreme external pressure, the color bands are nearly exactly the same as in Fig. *E*a. The stress is maximum at the inner face while the law of variations of stresses is practically the same as that established experimentally and shown in *E*b; the only exception being that the sign is due here to the compression strain.

The author discusses in detail such complicated cases as substances having defects of structure, or having annular forms subjected to tensile stresses applied diametrally, as in chain links. He passes then to the determination of the principal stress.

The cases of distribution of stresses considered above are such that one of the principal stresses at the point is very much larger than the other, while in several cases the minimum stress is zero. If, on the contrary, both stresses have certain values, it becomes important to separate them and to determine their magnitudes. If p and q are the main stresses at the point, the coloration is proportional to $p - q$ and this difference may be measured either by direct observation or by simple mechanical means. The measurement of the sum of principal stresses at the point is obtained by making use of the fact that the stress produces a variation in the thickness of the substances proportional to the sum of $p + q$ and this difference may be measured either by direct observation or by simple mechanical means. If, for example, both stresses are tensions, there will be produced a lateral contraction equal to $(p + q)/mE$ where E is the direct modulus of elasticity, m the Poisson ratio. The two latter quantities may be determined and the sum of the stresses deduced if one has a sufficiently sensitive extensometer for measuring the lateral contraction. The values of mE differ considerably for various substances, but in the artificially transparent substances used in this investigation they are considerably less than in metals, and their determination is much easier. The best value of E for xylonite is 300,000 (with pounds and inches as units), while m is about 2.5, so that for each 1,000 lbs. of strain applied, the corresponding lateral contraction on plates ⅛ in. thick is 1/6000 in. To measure such a quantity satisfactorily to one or two per cent, it is necessary to use an instrument capable of indicating the variation of about 1-100 of this quantity, and the author and Mr. Scoble have constructed a lateral extensometer capable of detecting a variation of about one-half millionth of an inch. Fig. *F* shows the construction of this apparatus. The frame *B* carries a micrometer screw *C*, the point of which touches the plate of transparent substance. This plate is opposite to a second piece *D* the inner end of which is slightly pressed against the plate by the spring *E* while the other end bears against the short lever arm *F*, carefully pivoted at *G*, controlling the angular position of a lever *H* of a mirror *J* pivoted at *K*. Every change produced in the thickness of the sample between the points causes a rotation of the mirror and may be observed by following the motion of the luminous point reflected from the mirror in the usual manner. The observations may be controlled by a micrometer screw, which for this case is provided with a graduated head *L*. The

points only bear against the face of the plate without penetrating into it so that the value of thickness as determined is exact.

A combination of the two above described means, with the sum of the two quantities determined by one process and the difference by another, necessitates extreme care in the determination of the exact values of each quantity, especially if one of the quantities is much less than another, since even slight errors of observation form important percentages of error in the value of the smaller quantity. As an example of this method, the author gives the measurement of a piece with a central hole in tension Fig. G. The values of $p + q$ and $p - q$ at the minimum transverse section are indicated on one of the diagrams as functions of the stress s, on the part of the plate which is not cut, while the separate values are given by the second diagram. Then by dotted lines are indicated a series of values calculated by theoretical calculation. The agreement of the two sets of values is remarkable as the test was rather severe since in this section, the radial stress q is slight while the tensile stress p is large, but the optical measurements show in an exact manner the characteristic valuations of p and q as well as the fact that the stress q must disappear at the exterior edges of the plate.

The author discusses in detail the determination of lines of principal stresses and shows by examples how this is done. He passes then to the application of the optical process to the case of shear stresses. To apply uniform shear stress to a plate made of transparent substance, he constructed a frame consisting of a pair of flat steel bars, holding the two long edges of a xylonite plate and clamped from both above and below by small and equal horizontal bars. As shown in Fig. H, a rectangular frame A is suspended by pin B from a supporting frame C of a simple lever testing machine of the Buckton type, and a central pair of holding bars R attached to a lower hook S holds the plate in such a manner that the equal rectangular elements T on each side of the central line are subjected to uniformly applied shear stress. In order to apply and change this stress, a spring balance D carried on the external knife of the testing machine is actuated by the wire E which passes over a guide pulley on to the screw F where, by means of the hand wheel G, one may in a few seconds obtain the desired stress. Shear stress produced at a given point may be determined directly from the coloring effect produced, but it is more convenient and exact to apply the zero method by using a piece placed in tension independently along the line of the main compression stress and placing on that test piece a load until the production of a dark field. The relation between the tensile stress I in the calibrated test piece and the shear S, at a point of the plate, is easily deduced from the fact that the shear, pure and simple, is determined by the numerical value of one of the main stresses p at the point, or, since the other main stress is equal to $-p$, the optical effect produced corresponds to $2p$. The shear stress may therefore be determined by placing the calibrated test piece in tension with its axis in line with the main stress of compression and increasing the tension until the production of a dark field of maximum intensity. The stress of the test piece while in tension is then numerically equal to twice the shear stress S. The apparatus used for this purpose consists essentially of a miniature testing machine with a frame, shaped like L, clamped to a vertical bar and pivoted about a horizontal axis. The tension on the testing piece is produced by means of a spring balance, one end of which is connected to the main lever, while the other end is connected to the frame by an adjustable screw. The author gives several examples of the application of this method.

Concerning the Causes of Trouble from Fungus on Telegraph Poles (*Über die Ursachen der Hausschwammplage an den Telegraphen-Stangen,* Karl Havelik. *Zeits. für Schwachstromtechnik*, vol. 7, nos. 23 and 24, pp. 633 and 656, December 1913. 5 pp., *pt*). The author discusses the curious fact that while on the Austrian side of the frontier a large number of telegraph poles impregnated with copper sulphate are strongly attacked by fungus (Merulius lacrymans), considerably less of these phenomena are observed on the other side of the frontier, especially in Germany. After a careful investigation he observed that poles which are placed in the sidewalk have the longest life; further that separate poles live many times longer than poles combined into the A-structure, while the latter are less long lived than similar poles in an H-structure. When he investigated the causes of these facts he found that poles placed in the sidewalk are surrounded by closer trampled earth, which forms part of the sidewalk itself. In addition, the single pole is in itself a very unstable structure, and unless placed in hard ground would be rapidly drawn out of its vertical position by the strains produced in stringing the wires. Therefore the earth all around the pole has to be well pressed in. It has been found that such a pole being fully protected from moisture, sometimes has a usage of 30 to 40 years, and when drawn out of the ground its cross-section gives an impression of perfectly fresh wood. Such poles begin to rot from the top, and by the process of center rotting are sometimes destroyed in a quarter of a century, though this period may be shorter if the upper part of the pole has not been well enough impregnated. On the other hand, poles which have been placed in the road itself are never fully protected from moisture, especially in the lower part in the earth. Therefore they rapidly develop center rotting, and are destroyed in a much shorter time than similar poles placed in the sidewalk, their period of life being somewhere around 18 years. The type of pole which particularly attracts the attention of engineers in Austria in connection with the question of rot is the A-shape structure which is, as the author points out, in itself so stable that no particular necessity is felt for hard pressing in the ground around it. On that account the ground is generally loose and the pole is always surrounded by moist earth. This produces a tendency to rot which affects this type of pole in particular. In several instances where a telegraph line has been made up partly of single poles and partly of combined A-poles, it has been observed that after a few years the A-poles have to be exchanged once, then twice, while the single poles are still in perfectly good condition. Investigations have shown that the A-poles are attacked by real fungi, while the author has never been able to discover the appearance of real fungi on single poles. It has been further noticed that the spread of the fungi on telegraph poles is not as uniform as in house timber, probably because the conditions of temperature and moisture in the house are more

uniform. In the case of the telegraph pole there is particularly intense rot on certain places, especially near the surface, while at the surface proper the temperature and moisture variations are so considerable as to make life impossible to real fungi. It is interesting to note that sometimes the A-combined poles are not attacked by fungi. This happens mainly when the pole is under water and the water prevents the access of air necessary for the life of the fungus. The author estimates that about 30 per cent of all the A-shaped poles in Austria are placed in swampy ground, and by this fact are protected from the action of the fungus, and as a result have a much longer life than other poles. Further, if right around the pole there is a large growth of vegetation, the pole is protected to a certain extent from the appearance of the fungus which is then unable to destroy the entire part of the pole under ground. On the contrary poles which have no vegetation begin to rot very intensively at the depth of about 50 cm. (say 20 in.) and are destroyed within a period of two to five years. As a matter of fact the author appears to consider that the great trouble with the A-shaped pole in its relation to rot is its great stability which allows it to be placed in loose ground, often with a little heap of earth around. In locations where a heap of earth around the pole would not be tolerated on account of its being an obstruction to traffic, and where there is no place to throw the earth taken out of the ground, this earth has to be stamped hard into the hole, and a situation is created similar to that around a single pole. In such places the life of the A-pole is considerably longer than elsewhere.

Besides the single pole and the A-pole in Austria, there is also used the *H*-type pole, especially where the sum of the diameters of the wires stretched over it exceeds 100 mm. (4 in.). At first sight it would appear that such poles would be attacked by real fungus just as much as the *A*-poles, since their placing requires just as large holes. As a matter of fact, however, this construction is not so stable as the other, and besides the pole carries such a large weight of wires that it must be placed quite rigidly. Therefore the earth is stamped hard and the very care with which it is done acts as a guarantee in protecting the pole from the action of fungi.

The Austrian telegraph administration has applied with eminent success several materials of impregnation for telegraph poles, such as copper sulphate. It has also used stronger poisons such as sublimate, zinc fluoride, bellitsesquifluoride and fluopotassate of zinc chloride. Such poles impregnated with quick acting poisons have been placed in locations where the poles were attacked with particular rapidity, and have proved to be quite long lived and practically free from the attacks of the real fungus. As regards the prevention of internal rot the author recommends that the parts of poles impregnated with copper sulphate or zinc chloride be placed in either sublimate or zinc fluoride for several days submitting to this supplementary treatment such parts of the pole as will be later placed under ground.

Miscellanea

On Electric Conductivity of Gases and Steam Issuing from Steam Locomotive Smokestacks (*Sur la conductibilité des gaz et vapeurs émis par les locomotives à vapeur*, M. Parodi. Société internationale des électriciens, vol. 3, Ser. 3, no. 30, p. 1009, December 1913. 5 pp. *ep*). Many times, difficulties have been encountered in the operation of electric railroads using high-tension single-phase or three-phase currents simultaneously with steam locomotives. It has been found that mainly in tunnels and under bridges ruptures in insulators are produced, and arcs started between the lines and the supports of the insulators in the roof of the tunnel or bridge, even though the insulation has been designed on generous lines and has been tested at voltages three or four times above the normal voltage of the line.

Attempts have been made to explain this phenomenon by ascribing it to the action of deposits of soot and carbon on the insulators, but this explanation does not hold, since tests made by different engineers and repeated by the author, have shown that insulators covered on purpose by a thick layer of carbon deposits have proved to possess practically the same qualities as new clean insulators, both with respect to insulation proper, and to dielectric rigidity. It appears therefore that the cause of these difficulties on high-tension lines is to be sought in another direction and the author found that the starting of the arcs may be ascribed to reduction of the dielectric strength of the surrounding medium, due to ionization of the steam and gases issuing from the smokestacks of steam locomotives. As a matter of fact, the possibility of such ionization has been proved by the electrostatic machine of Armstrong which works on the principle of electrification by friction of moist steam escaping from a nozzle. In this machine a little boiler insulated from the earth generates steam and after passing through water lets it escape through a nozzle in a manner such that the steam strikes a conductor also insulated from the ground. The conductor is then charged positively while the boiler acquires a negative charge and with the pressure of steam of 8 to 9 atmospheres, long sparks may be drawn from the conductor practically without interruption. In the case of steam locomotives the phenomenon is somewhat dissimilar to that which takes place in the case of the Armstrong machine, since the locomotive is grounded, but the Armstrong experiment shows that gases and vapors coming out from the stacks of steam locomotives must be electrified and therefore act as conductors. To prove the presence of such ionization the author made direct experiments, measuring, on one hand, the charges transmitted by means of an electroscope and on the other hand measuring the distances of spark passages in the electrified gases. After the electroscopic tests experiments were made with locomotives with the steam up, but stationary, and the jet blower working. By varying the operation of the blower the composition of the gases coming out from the smokestack may be varied at will and a mixture containing more or less steam obtained. By placing the test plane of an electroscope over the smokestack of a steam locomotive it is found that it charges the electroscope in the usual manner and that the gases and steam which issue from the locomotive appear to be negatively charged. If the test plane is directly connected to the electroscope terminals, the electrification is so intense that the electroscope leaves are sometimes torn off.

Similar experiments have been made in order to determine the break-down voltage between plane and sphere at a constant distance from each other with the locomotive under them, and without, and it has been found that this voltage varies as follows:

	Breakdown Voltage (Volts	
	Locomotive under Spark	Locomotiv Removed
Blower closed	5544	9150
Blower half-open	4224	9150
Blower wide open	3960	9150

Since the output of the jet blower of the locomotive is only about one-tenth of the locomotive in working order the above figures indicate only the tendency of the phenomenon and not its actual intensity. They show, however, that the electrification of the air and the reduction of the breakdown voltage due to the ionization of the locomotive gases and steam are sufficient to explain the constant disturbances in the working of certain high-tension installations. Naturally, this phenomenon would be particularly noticeable in tunnels where the steam and gases of the locomotives accumulate in the upper part and form a sort of ionized cloud electrically connecting the walls of the tunnels with the high-tension conductors. In tunnels which are not properly ventilated and sometimes under bridges, this cloud disperses very slowly so that when an electrically drawn train comes through it, soon after the passage of a steam locomotive, an arc may start between the conductor and the ground even though the voltage used does not exceed the regular tension of the line. It may be roughly stated therefore that in order to avoid arcs in poorly ventilated places where steam and gases from locomotives may accumulate, the thickness of gaseous dielectrics must be at least two or three times as large as that used in places where ionized gases have no chance to accumulate. At the same time there are devices that will facilitate the elimination of the ionized gases, and ventilation especially will improve the installation of a high-tension electric line operated simultaneously with steam locomotives.

The author calls attention also to an easily observed fact which gives ocular evidence of the truth of his statement and which may be observed in the neighborhood of high-tension single-phase lines. Locomotive smoke in the neighborhood of the electric traction lines oscillates at a frequency equal to that of the line system. This phenomenon is often evident at night if the line is lighted by electric arc lights fed by current having also the frequency of the traction line. This synchronous vibration can be simply explained only by ascribing it to the ionizing action of the gases and smoke coming out from the stacks of the steam locomotives.

ENGINEERING SOCIETIES

AMERICAN CONCRETE INSTITUTE

Journal, vol. 1, no. 1, November 1913, Philadelphia

Report of Committee on Standard Specifications and Methods of Tests for Concrete Materials (Abstracted)

Effects of Electric Currents on Concrete, E. B. Ross, Burton McCullom and O. S. Peters

No. 2, December 1913

Effects of Electric Currents on Concrete, concluded

The Development of Concrete Grain Elevator Construction, R. P. Durham

Report of Committee on Standard Specifications and Methods of Tests for Concrete Materials (10 pp. *g*). Tests of the individual materials are not sufficient for determining the quality of the concrete made from them. A certain sand may give satisfactory results with one brand of cement and prove a failure with another. A sand of a certain granulometric composition may require an entirely different proportioning with one coarse aggregate than with another or may be unsuited for use with it because of the sizes of the grains.

Fine Aggregate. Sand or other fine aggregate should always be tested. In ordinary cases where special characteristics are not required, the test for acceptance is the determination of the strength of mortar made up with the cement and fine aggregate to be used on the work in comparison with the strength of identical specimens made with standard sand. The results of this test are also an aid to the selection of the proportions which should be adopted.

Compression tests of mortar are the most reliable, but tensile tests may be employed when a compression machine is not available.

Requirements for Strength. The aim in concrete construction should be to obtain a sand which produces a 1:3 mortar equal in strength to a similar mortar of a standard Ottawa sand. Sands producing mortars having a strength of less than 70 per cent of standard sand mortar should be rejected.

Between these two limits the variations in strength should be taken into account in fixing the proportions of the mortar or concrete.

The Committee sent out a circular letter of inquiry to various laboratories asking for information on various steps taken in testing cement, and from the answers received composed the following list. (Of course, not all laboratories use all methods):

1 *Examination of Deposit* to determine its uniformity, stratification, extent, overburden, methods of stripping, handling, screening, washing, etc.

2 *Preparation of Sample* to eliminate stone, water, silt, and to insure its being representative of the bank or the quantity from which it was taken.

3 *Tensile Test of Mortar* to determine the strength of known mixtures of the sand and portland cement at various ages and to compare this strength with that of standard Ottawa sand

4 *Compressive Test of Mortar* to determine the strength of known mixtures of the sand and portland cement at various ages and to ascertain what mixture is necessary to produce a required strength, or impermeability.

5 *Compressive Test of Concrete* to determine the strength of known mixtures of the sand and a coarse aggregate and portland cement at various ages and to ascertain what mixture is necessary to produce a required strength or impermeability. In the case of bank gravel or crushed stone which is not to be screened and reproportioned this test is used instead of No. 4.

6 *Percentage of Moisture* is determined in order to allow for the water contained in the sand in proportioning mixtures, computing freight rates, etc.

7 *Percentage of Voids* is determined:

a By determining the specific gravity of the solid particles and weighing a known volume of the sand and computing therefrom the percentage of voids.

b By filling the voids in a known volume of sand with a measured amount of a liquid.[1]

8 *Yield, or Volume of Mixtures* is determined by adding a known quantity of cement to a known quantity of the sand, wetting the mixture and noting the increase in the volume of the sand. This is repeated with various proportions of cement and sand to ascertain the amount of cement required to fill the voids in the sand.

[1] This method as usually practised is very inexact on account of the air entrained

9 *Density of Mortar and Concrete* is determined for various mixtures of cement and sand and of cement, sand and stone to ascertain that mixture which gives a material of the greatest weight per unit of volume.

10 *Specific Gravity of Solid Particles* is determined by three different methods:

a By the specific gravity apparatus, such as the Jackson flask.

b By pouring a known weight of sand into a known volume of water and noting increase of volume of liquid.

c For coarse aggregate by suspending pieces by a thread on chemical scales and noting weight in air and weight when hanging in a jar of water.

11 *Specific Gravity of Sand* including voids is determined by weighing a known volume of the sand exclusive of moisture and computing the specific gravity from the known weight of the same volume of water. Having determined the specific gravity of the solid particles (test No. 10) and also that of the sand (including voids) the percentage of voids in the sand may be calculated.

12 *Weight per Cubic Foot* is determined by weighing a known volume of the sand. This test is very closely related to test No. 11.

13 *Granulometric Analysis or Mechanical Analysis* is made by passing a known weight of the sand through a series of sieves of various sizes and noting the amount retained on each sieve and the amount passing the finest one. This test shows the distribution of the particles from fine to coarse.

14 *Uniformity Coefficient* is determined from a curve plotted from the granulometric analysis by dividing the diameter of the particles at the point where the curve crosses the 60 per cent ordinate by the diameter of the particles at the point where the curve crosses the 10 per cent ordinate.

15 *Wet Screening* of a sand on the 100 and 200-mesh sieves shows the amount of fine material which can be washed from the sand and which in the case of dry screening in test No. 13 often adhere to the larger particles and so leads to uncertain results.

16 *Silt Suspended in Water* is determined by agitating a quantity of the sand with a large excess of water in a tall cylindrical glass vessel and noting the amount of silt which becomes suspended in the water and later settles down on the top of the sand.

17 *Silt Washed Out* is found by agitating a known quantity of the sand in water, allowing the coarse particles to settle and decanting or syphoning off the muddy water from the top. This operation is repeated until clear water is obtained. The amount of silt washed out is determined after evaporating the water.

18 *Loss on Ignition* is determined by heating to a red heat a weighed quantity of the dried sand and again weighing after cooling. This test is best performed only on the silt washed from a quantity of sand as the silt usually contains the injurious organic constituents of the sand.

19 *Organic Matter* is sometimes determined after the methods employed by the agricultural chemists.

20 *Chemical Analysis* is made to determine the character of the sand grains. Only a few of the most common rock constituents are usually determined quantitatively, for the purpose of judging of the strength and durability of concrete made from the sand. A high silica content is usually desired.

21 *Microscopical Examination* is made to ascertain the approximate size of the grains, their shape, character of surface and to detect the presence of objectionable material or foreign matter, such as mica or small roots or a coating on the grains.

22 *Absorption of Mortar and Concrete* made from the sand mixed in varying proportions with cement, or cement and stone, is determined to ascertain its suitability and the proper proportions for the production of a product having a minimum of absorption.

23 *Permeability of Mortar and Concrete* made from the sand is sometimes determined for various proportions of the constituents in order to determine mixtures for the production of an impermeable mortar or concrete.

24 *Effect of Different Cements* on some sands is quite variable and tests are sometimes made to determine with which of several available cements the sand will give best results.

25 *Freezing* during the setting time has a more injurious effect on mortar and concrete made with some sands than those made by others, and tests are made to determine the extent to which the sand is affected by freezing.

26 *Fire* has a more disastrous effect on some sands when used in mortar or concrete than it has upon others and a heat test is made to show the ability of the sand to resist fire.

ENGINEERING ASSOCIATION OF THE SOUTH

Journal, vol 24, no. 4, October, November and December 1913, Nashville

Methods and Costs of Drag-Line Excavation, James Allen Barr (Abstracted)

Development of Southern Assembly Grounds, Near Waynesville, N. C., J. W. Seaver, Jr.

METHODS AND COSTS OF DRAG-LINE EXCAVATION, J. A. Barr (8 pp., 3 figs. *dh*). One of the first drag-line excavators was constructed by John W. Paige, who used a stiff-leg derrick and double-drum hoisting engines for lock work on the Sault Canal, at Sault St. Marie, Mich. In 1909-1910 the modern steel machine appeared, in which the chief improvement was the design of special engines adapted to the work instead of employing ordinary hoisting engines. The caterpillar traction, now an exclusive Bucyrus feature, was first applied by them to a gasolene drag line in 1912.

The drag-line Excavator is preëminently a machine for wasting or borrowing loose dirt. Especially where it is impossible to get cars close to a standard shovel or where a pit is under water or too wet, the drag line is the next machine to be considered. While the standard shovel is unequaled for close range work, still the drag line can do the same class of digging, but at a greater cost.

These machines can be used to dig sand and gravel under water where the depth is not too great by reaching out from the bank of the stream and moving ahead when necessary. This class also includes placer mining where the scale of operations or the initial investment precludes the installation of a regular dredge.

For digging ditches in drainage work the Class 9½ drag line is one of the best machines that can be used It is light and quick, and can be made to handle a large amount of dirt for its size For ditch work the machine should be provided with a caterpillar traction, which will give it a wide radius of action with a small moving cost. As long as the ground remains reasonably firm, rainy weather has no terrors for the drag line, the operator being protected

The drag line is successfully handling sand, clay, brick

shale, pipe clay, adobe, soft sandstone, bog iron ore, rotten limestone, powder-broken rock, or anything else that can be moved by a man with a pick and shovel. In Colorado a drag line wasted a rock cut that broke well upon shooting. In digging through a virgin forest in Arkansas a machine regularly pulled stumps after they were loosened with powder. The smaller ones, from 24 in. to 30 in., were dug around and then pulled directly.

OPERATING COSTS

Since the Class 14 is the average size used, its costs will be used for a general illustration.

One runner, $150 per month and board, for 25 shifts, including Sunday repair work	$6.00
One fireman	2.50
One team driver	1.75
One ground man	1.50
If machine runs on timbers instead of caterpillars, add one man.	
One foreman	3.00
One team (if owned by company)	3.00
Coal, 2 tons at $2.40	4.80
Cable wear	5.00
Repairs, supplies, oil, etc	3.00
Interest at 6 per cent	1.16
Depreciation at 10 per cent	3.50
Total cost per 10-hour shift	$35.21

If the machine could dig continuously, this would be 3½ cents per yard; but since it must move and occasionally lie idle, the average cost per job will be safely figured at 6 cents per yard under average conditions.

ENGINEERING SOCIETY, UNIVERSITY OF NEBRASKA

The Nebraska Blue-Print, vol. 13, no. 4, 1914, Lincoln

Calcium Hypochlorite Disinfection of Water, H. P. Letton
Test of York Ice Machine, C. L. Dean (Abstracted)
Paving, Pavements and Paving Materials, A. C. Smith
Essentials of Error Theory (*A*), L. B. Tuckerman, Jr.

TEST OF YORK ICE MACHINE, C. L. Dean (8 pp., 5 figs. *e*). The article gives complete data of a 69½ hours test of a York Ice Machine made in the College of Engineering of the University of Nebraska in 1913. For the detailed tables of data reference should be made to the original article.

The plant consists of two vertical single-acting ammonia compressors, 7½ in. bore by 10 in. stroke. The steam cylinder is of the horizontal type, having Corliss governor and valve gear, being 11½ in. bore by 10 in. stroke. The flywheel of this machine is 4 ft. in diameter and weighs 3000 lb. The ammonia condenser is of the double pipe style, the pipes being 1¼ in. and 2 in. diameter, each coil being ten pipes high and 18 ft. long. The freezing tank is of ¼ in. steel, 13¾ ft. long, 7 ft. wide and 4 ft. deep. It contains 35 freezing cans 8 in. by 15 in. by 35 in. of 100 lb. capacity. The brine coil consists of one section of double pipe, 2 in. and 3 in. in diameter, 6 double pipes high and 12 ft. long. The brine pump is a Duplex brass fitted pump 4½ in. by 3¾ in. by 4 in. An automatic thawing and dumping device is used for freeing the ice from the cans.

Thermometer wells are placed at all points where temperature is to be noted, and both steam and ammonia cylinders are fitted with reducing motions for the taking of indicator cards. A throttling calorimeter was used to determine the moisture in the steam, and Tabor indicators were used on all cylinders.

A meter registered all water used in jackets and ammonia condenser, the water from jackets being weighed as discharged, and this being taken from meter reading, gives water used in ammonia condenser. The condensed steam and condensing water was weighed directly.

The speed of both brine pump and engine was registered by attached counters. The amount of brine in the freezing tank was calculated from measurements and found to be 263 cu. ft. or 19,840 lb.

Temperatures were taken as follows: At suction pipe entering ammonia compressor; at each discharge pipe leaving ammonia compressor; ammonia entering condenser; ammonia leaving condenser and liquid receiver; ammonia entering expansion coil; ammonia leaving expansion coil; brine entering cooler; brine leaving cooler; room temperature; outside temperature; ammonia compressor jacket water, incoming; ammonia compressor jacket water, outgoing; ammonia condenser jacket water, incoming; ammonia condenser jacket water, outgoing; throttling calorimeter, upper and lower thermometers.

Following is tabulated the average data taken for each four hours of the test (lack of space will not permit the entire tabulation, and the results of the two parts of the test).

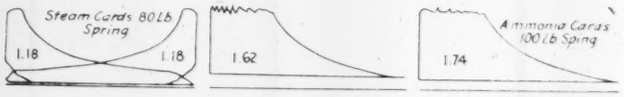


FIG. 9 INDICATOR DIAGRAMS FROM THE TEST OF A YORK ICE MACHINE

DATA AND CALCULATIONS, YORK MANUFACTURING COMPANY, 10-TON PLANT

Cylinder	Size, In.	Area Sq. In.	Diameter Rod, In.	Constant
Steam	11½ x 10	102.49	1⅞	0.00259
E. Compressor	7½ x10	44.18	1⅝	0.00111
W. Compressor	7½ x10	44.18	1⅝	0.00111

Cylinder	Length of Card, In.	Scale of Spring, Lb.
Steam	2.9	80
E. Compressor	3.00	100
W. Compressor	3.00	100

QUALITY OF STEAM

$$X = \frac{H - h + .48(t_2 - t_1)}{L}$$

H at 330 deg. = 1186.9
L at 330 deg. = 886.3
h at 212 deg. = 180

$$X = \frac{1186.9 - 180 + .48(272 - 212)}{886.3}$$

1.1 per cent moisture
Quality = 98.9 per cent

t_1 = temperature at atmospheric pressure
t_2 = temperature at lower thermometer

FIRST PART

Tank contains 263 cu. ft. brine
Density of brine = 1.207
Weight of brine = 263 × 1.207 × 62.5 = 19,840 lb.
Specific heat of brine = 0.8097
Temperature fall of brine = 64 deg. — 6.5 deg. = 57.5 deg. fahr.
19,840 × 0.8097 × 57.5 = 923,680 B.t.u. taken from brine
Allowing 3 lb. loss per can = 105 lb.
3790 + 105 = 3895 lb. ice
54 deg. — 32 deg. = 22 deg. temperature of water above freezing at beginning of test
3895 × 22 = 85,700 B.t.u. heat taken from water above freezing temperature
Latent heat of water = 142
3895 × 142 = 553,160 B.t.u. latent heat of fusion
Specific heat of ice = 0.504
32 deg. — 6.5 deg. = 25 deg. temperature of ice below freezing

$3895 \times .504 \times 25.5 = 50{,}060$ B.t.u. taken from ice

923,680
85,700
553,160
50,060

1,612,600 B.t.u. total

B.t.u. taken out per ton of refrigeration = 284,000

$\frac{1{,}612{,}600}{284000} = 5.60$ tons refrigeration

Length of test $37\frac{1}{2}$ hours

$\frac{5.68 \times 24}{37.5} = 3.63$ tons refrigeration per day

Average h.p. = 9.04

$\frac{9.04}{2.63} = 2.49$ h.p. per ton refrigeration

3895 lb. = 1.95 tons of ice

	Per Ton Refrigertion	Per I.H.P.H.	Per B.H.P.H.
Jacket water.....	607		
Ammonia condensing water.	13570		
Condensing steam, wet...	2915	48.8	63.4
Condensing steam, dry...	2880	48.3	62.7
Condensing water.....	50900	852	1108

During the second part of the test the cans were emptied and refilled as fast as frozen and the results here shown.

Total weight of ice made = 4643.6 lb.

Length of test = 32 hours

Average h.p. = 9.47

4643.6 lb. = tons of ice

	Per Ton Refrigertion	Per I.H.P.H.	Per B.H.P.H.
Jacket water.....	1355		
Ammonia condensing water.	17310		
Condensing steam, wet...	4175	42.7	55.6
Condensing steam, dry...	4130	42.2	55.6
Condensing water.....	73300	748	976

INSTITUTE OF MARINE ENGINEERS

Transactions, vol. 25, January 1914, Stratford

THE GYROSCOPE AND GYROSCOPIC ACTION IN ENGINEERING PRACTICE, Thomas R. Thomas. (Lecture delivered to the Institute on October 20, 1913. 40 pp., 10 figs. *gt*). The paper presents a general theory of the gyroscope and a discussion of some of its applications. In view of the fact that the theory of the gyroscope is fairly well known, only certain parts will be reported here. In discussing the application of gyroscopic action, both intentional and unvoluntary, the author calls attention to its occurrence in locomotive wheels when running around a sharp curve. In the case of an engine taking the right-hand curve, the front of the wheel would be moving to the right as compared with the center, and the bottom would consequently be forced in the same direction. This action is partly compensated for by keeping the outer rail higher than the inner, thus causing the weight to fall inwards; but the stress set on the axles must be appreciable. Another interesting example of gyroscopic action is found in the aeroplane—especially in one fitted with engines of the rotary type. Assume that the engine is of the Gnome type, rotating clockwise. If the rudder is put very sharply about, so as to bring the head of the machine around to the right, gyroscopic action forces the head downwards. If the pilot is expert and far enough from the ground, he can correct the effect of the dip, but on the other hand, if he is near the ground, he may be in considerable danger. On the Wright machines twin propellers are used, in this way correcting each other to a great extent, but not entirely, as they run in opposite directions. If the propellers were placed one behind the other, or one a tractor and the other a propeller, the compensation would be perfect. Further, it often happens that in a rotating wheel the center of gravity of the rotating mass is not in the center of rotation. A wheel may be perfectly machined and when tried in a lathe appear to be quite true, and yet when run at high speed it may run considerably out of true if the shaft is sufficiently flexible, which is due to the fact that the metal in the wheel is not homogeneous. The curious thing is that such a wheel when running at a certain speed, termed the critical, will become perfectly true, while at lower speed it will throw considerably. The author explains this phenomenon by gyroscopic action. In Fig. 10A a wheel fixed on a flexible spindle and running in bearings *BB* is shown. It is assumed that the spindle is uniform in action throughout. The wheel is exactly central between the bearings and the center of gravity is at *A*, a little away from the axis of rotation but exactly equidistant from the bearings. When the wheel is rotating, centrifugal force would bend the spindle until it took the form shown by the dotted lines. The wheel would be out of true radially, but quite true sidewise, with the eccentricity tending to increase with increase of speed, opposed only by the rigidity of the spindle. In actual practice such conditions would occur only rarely, if ever; more likely it would be found either that *A* is not exactly equidistant between the bearings or that the shaft is not uniform in section on both sides of the wheel. Suppose, then, a wheel mounted as shown in Fig. 10B with *A* in the same position radially as in the previous case but not equidistant between the bearings; then the wheel would not only throw radially but would also be inclined toward the original axis as shown by the dotted lines. With the wheel rotating, the top away from the spectator, gyroscopic action would force the part of the wheel nearest to the left, and then the top would be forced to the left. As this action is occurring all around the wheel, the spindle is set vibrating with a period equal to the time of revolution. The wheel will oscillate sidewise, or precess in the manner of a spinning top, but the precession will not be free unless the revolutions coincide with the actual period of vibration of the shaft. When they do, the wheel will at once spin true. If the time of revolution does not coincide with the period of the shaft there will be periods of wobbling when they are not in phase, and periods of stillness when they are. Precession will be retarded in the first case and accelerated in the latter. The author discusses also gyroscopic movements of a flywheel when inclined from the plane of rotation.

In the discussion which followed, Mr. E. Kilburn Scott mentioned that some 20 years ago a company for whom he worked supplied some ship lighting sets of electrical machinery, which, to economize space, were fixed with their axles *across* the ship; but it was found that the shafts were very liable to breakage when in this position owing to the gyroscopic action combined with the rolling of the ship. The difficulty was removed when the sets were placed with the shafts in a fore and aft position. Most gyroscopes in practical use run at about the same peripheral speed as that adopted by Mr. Brennan who, on his monorail car, used a wheel 4 in. wide and 3 ft. 6 in. in diameter, running at 3000 r.p.m., with the peripheral speed of about 33,000 ft. per sec.

The particulars of the various gyroscopes are given in Table 1.

The Anschutz wheel has been tested to destruction and

TABLE 1 DATA RESPECTING VARIOUS TYPES OF GYROSCOPIC WHEELS

	Used for	Diameter of Wheel, In.	Width of Wheel, In.	Speed, R.P.M.	Peripheral Speed, Ft. per Min.	Approx. Weight Wheel in Lb.	Material of Wheel	Type of Motor
Brennan	Monorail model	6½	2	2000	3400	7	Gun-metal	Direct current
Brennan	Large monorail car	42	4	3000	33000	1500	Nickel steel	Two direct current motors on each shaft
Anschutz	Compass	6	1	21000	32800	9	Nickel steel	Three-phase motor inside rim
Sperry	Compass	12	2	8600	27000	43	Vanadium steel	Three-phase motor inside rim

neither the rim nor the web have given way; it was the shaft that broke first. The peripheral speed of about 66,000 was obtained, calculated to equal 750 miles an hour, and yet the steel in the rim did not break. The spindle of the Anschutz gyrowheel is on the principle of the De Laval turbine—very small in diameter so that the wheel can find its own center of gyration. The shafts of the Brennan and Sperry wheels are stiffly built and everything depends upon the most accurate balancing. Mr. J. W. Gordon distinguished between a gyroscope and a gyrostat: calling the former the spinning member, and the latter, both spinning member and mounting frame. This distinction is of importance because the frame has the same properties as the gyroscope, being

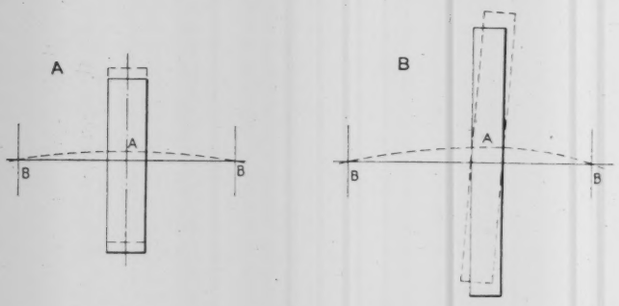


Fig. 10 Gyroscopic Action on a Wheel Having the Center of Gravity Not in the Center of Rotation

connected to the wheel in a manner such that it has to share in all the motions of the wheel except the spinning motion. The gyrostat therefore possesses all the properties in precession of the gyroscope, but there is one very important distinction between the two: The gyrostat has special properties in reference to what the author calls constrained precession, which may occur when the center about which one precession takes place coincides with the center of gravity, whereas the center about which the other precession takes place is at a distance from the center of gravity.

INSTITUTION OF MECHANICAL ENGINEERS

Advance publication, C, read January 16, 1914, London

Commercial Tests of Internal-Combustion Engines, W. A. Tookey (19 pp., 6 figs. *epA*). The paper describes methods of commercial tests of internal-combustion engines based on the experience of the author, who, during the past few years, made tests on over 700 gas engines of various sizes and makes. The author worked out the test sheet shown in Table 2. His experience with internal-combustion engines has indicated that the strength of mixture, although one of the most important matters which should be determined in all tests, is seldom taken into account in trials. In a former article (*Engineering*, October 15, 1909) he showed that the influence of mixture strength upon the thermal efficiency of internal-combustion engines was at least of equal importance with the compression ratio. He believes that equal thermal efficiency can be obtained through a wide range of compression pressures and from varying mixture strengths, providing the admission is properly correlated; by increasing the mixture strength, and delaying the firing point, higher mean pressures can be obtained with little, if any, loss of efficiency within certain limits.

Throughout the series of commercial tests, the author computed the mixture strength of the charges taken in by various engines in terms of total cylinder contents, that is to say, gas, air and residuals, and then comparing with the mean pressure (positive loop) calculated from intersecting diagrams. The factor, *mean pressure* mixture strength, has been of invaluable aid in deciding the steps to be taken to obtain better results from all the engines inspected. In order to express the mixture strength in terms of total cylinder volume, it is necessary to note the clearance volume as well as the piston displacement. The latter can be calculated from the cylinder dimensions of an engine, but the former, in commercial tests, cannot be definitely measured, although a close determination can be obtained by observing the compression pressure attained, and also by noting the volumetric efficiency of the engine.

The author describes in detail how he obtained all the data tabulated in the above table. He points out among other things that the compression curve exponent 1.30 appears to hold good for gas, gasolene, and oil engines varying widely in design within close limits, so that it appears probable that computations based upon the exponent 1.30 give sufficiently accurate data for ordinary commercial testing purposes. As regards the question of the weight of the mixture, he points out that, for commercial purposes, the internal-combustion engineer has no need of it, and if he can obtain information as to the relative mixture strength in B.t.u per cubic foot of effective cylinder volume it will be sufficient. But in the absence of knowledge as to the mixture strength used, he is absolutely in the dark and has to face the confusing situation that with one engine of a certain size coming on to the testing bed, the rated power, or consumption, may be readily obtained, while with perhaps another engine of the same or a different batch, he finds it extremely difficult to obtain the "list" figures for output or for efficiency. Without a knowledge of the mixture strength with which the engine is working and at which the engine works best, he cannot be certain that the test-bed adjustments are final.

The author points out that very efficient cooling and care-

ful adjusting of ignition-timing devices are required when the engines are called upon to deal with loads necessitating a continuity of explosions, producing mean pressures of the order of 90 lb. per sq. in., such high pressures being by no means uncommon in everyday work. The author believes that there is little doubt that gas engines rated by the makers upon the basis of 80 lb. per sq. in. for continuous work actually possess considerable reserve of power. However, the

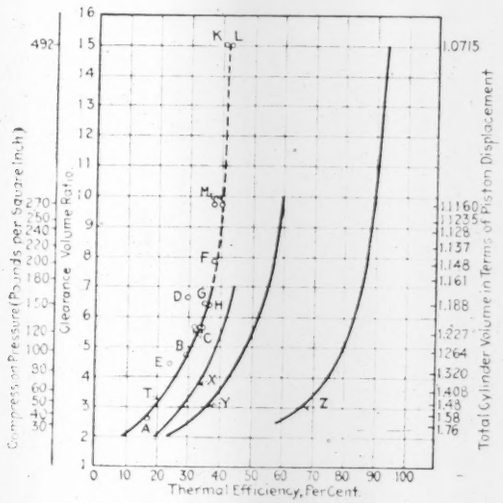


FIG. 11 CURVES OF TESTS OF INTERNAL COMBUSTION ENGINES

THERMAL EFFICIENCY, PER CENT

Z Increasing efficiency with increasing compression pressure due, by reason of reduction in clearance volume, to lesser total quantity of heat required to maintain equivalent mixture strength.

Y Air standard efficiencies on basis of constant specific heat (Institution of Civil Engineers Committee, 1905).

X Clerk's corrected efficiencies on basis of varying specific heat (Junior Institution of Engineers, Canet Lecture, 1913).

T Tookey's curve of practical efficiencies ($Z \times X = T$).

The circles and dotted continuation of curve *T* show the actual efficiencies obtained by various experimenters during thirty years (1881 to 1911), as accompanying table, and their close agreement with Tookey's curve.

Reference Letter	Test by	Maker of Engine	Date	Size of Engine, B.H.P.
A	Slaby	Otto	1881	4.5
B	Humphrey	Crossley	1900	360
C	Inst. C. E.	National	1905	*L*, *R*, and *X* engines
D	Stead	National	1911	750
E	Clerk	Crossley	1894	12
F	Burstall	Crossley	1904	50
G	Atkinson	Crossley	1905	40
H	Hopkinson	Crossley	1908	40
K	Longridge	Diesel	1905	500
L	Longridge	Diesel	1905	80
M	Robinson	Ruston	1910	50

manner in which engines can be run at these other loads is very rarely understood by men in whose charge they are placed. While until recent years no appliances were provided, by means of which the necessary adjustments could be made to obtain this much to be desired end, the only limit to an engine's capacity for overloads within the above mentioned range is the liability of preignition of the charge during the final portion of the compression stroke. The more nearly the temperature reaches a certain critical point, either by heat generated during the combustion or by cylinder wall radiation, the more nearly probable appear the higher efficiencies. The output of power depends upon the mixture strength; the richer the mixture, the more powerful the impulse in terms of mean pressure; but if the load demands a mixture so rich that the combustion when once started proceeds with extreme rapidity under the temperature due to compression and wall radiation, then preignitions are set up spontaneously, producing violent bumping and quickly bringing the engine to a standstill It is for this reason that engines governed by the "hit and miss" system can be worked continuously at high mean pressures without giving trouble; even if but one miss occurs at intervals of, say, 20 cycles, the engine will work quite satisfactorily, probably due to the fact that the air admitted during the miss, instead of creating turbulency, very effectually cools the skin of the internal wall below the critical temperature, which water circulation alone is unable to reduce. On the other hand, in throttle governed engines, preignitions are much more likely to give trouble since under heavy loads the compression pressure and temperatures are high and more heat is given to the walls.

Prior to the discussion, the author explained a chart shown in Fig. 11, which he had prepared to bring out certain points in relation to mixture strength. This chart and the following passages were not published with the advance copy of the paper, but were reported from the London *Engineer* of January 22, 1914, Page 108. The horizontal lines refer to clearance volume pressures; the vertical lines show thermal efficiency in percentage. The chart showed the variations which different authorities said were to be expected from any internal-combustion engine in terms of compression pressure, or, what amounted to the same thing, compression-volume ratio. The curve *Y* was that referred to by the Research Committee of the Institution of Civil Engineers in their report in 1905 on the basis of a constant specific heat. It had been promised that as compression pressure went up, higher thermal efficiencies would be obtained, but practice did not bear out that theory. Dugald Clerk had, among others, set to work to find out why that was not so. The curve *X* was taken from Dr. Clerk's figures, allowing for variation in the specific heat of the working fluid of internal-combustion engines. The curve was much nearer the *Y* curve at ratio 2 than at ratio 7, showing that, on going higher, the varying specific heat of the working fluid tended to make the engine become less efficient.

Another curve *T* is shown and along it are certain dots. The lower part of the curve (marked in full) has been calculated; the upper part has been elongated and drawn out to make it agree with the test representing the actual efficiencies that had been obtained during the last 30 years by different experimenters with internal-combustion engines of varying compression ratios.

JUNIOR INSTITUTION OF ENGINEERS

Journal and Record of Transactions, vol. 24, pt. 4, January 1914, London

Engineering Business, J. H. Rosenthal

The Future of Oil Fuel, Sir Roverton Redwood (Abstracted)

THE FUTURE OF OIL FUEL, Sir Roverton Redwood (34 pp., 1 fig. *gs*). This paper was delivered as a presidential address to the Junior Institution of Engineers by the author, who is well known as one of the great authorities on oil fuels.

After discussing the various uses of oil fuel and sources of supply, the author passes to the future of oil fuel and expresses a belief that it depends not only upon the extent to which the output may be reasonably expected to increase, but largely upon the manner in which the fuel is to be used, since in the light of our present knowledge the supply of oil fuel cannot be expected to increase to such an extent as to give consumers in general a free choice in substituting oil for coal as a source of power for industrial purposes, especially if the oil is not used in the most economical manner. The petroleum industry is unquestionably capable of much greater expansion. The use of oil fuel will undoubtedly largely increase. But it is evident that with all the rich new fields that may be expected to be developed, it will require a very considerable expenditure of capital directly to increase the average rate of expansion of the petroleum industry, especially in view of the fact that some of the older oil fields are showing signs of exhaustion. So far as the future can be at all predicted, there will doubtless be a large and continuous increase in the requirements of the navies of the world; as this demand is not primarily governed by price, it may be described as "irresistibly preferential" in character, taking precedence therefore over all industrial needs. Further, rapid progress may be expected in the use of more volatile products in road motor vehicles and in some countries there will doubtless be a greatly extended employment of oil fuel on the railways. Considered, however, as a source of power generally, it is improbable that the oil will be used otherwise than in an engine of Diesel or semi-Diesel type. As regards the use of oil as a source of power outside of the war navies of the world, it is evident that it must depend upon the price at which the fuel can be obtained. When the market value of oil fuel becomes established on what may be termed the Diesel engine basis, it is only those who occupy exceptionally favorable geographical positions with respect to the source of supply who could employ that sort of fuel in steam raising.

In conclusion, the author vigorously pleads for economy in the production of petroleum and calls attention to the fact that immense sums have been thrown away in haphazard drilling operations while valuable oil fields have been destroyed by reckless procedure.

TABLE 2 MR. TOOKEY'S FORM FOR TABULATING DATA OF COMMERCIAL TESTS OF INTERNAL-COMBUSTION ENGINES

Test No. 595A — Date: 13 Feb. 1913
Name: S. & Co. — 2 Meters: 300 lt. No. 906089
Address: Bermondsey, S. E. — 300 lt. No. 37388
Assistant's Initials: A. R. P.
Machinery driven: Dynamo and cocoa-grinding plant.
24" × 30" (———) Gas Engine No. 10841.

R.p.m. { Light: 155
Load: 154

Specific piston displacement $\left(\frac{A. \times S.}{1728}\right) = 7.854$ cu. ft. per stroke

Governor: Hit-and-miss

I.h.p. constant $\left(\frac{A. \times S.}{396{,}000}\right) = 0.03427$

Ignition: Two magnetos (low tension)

Piston positions from edge of liner—in-center: 23.375" in; out-center: 6.625" out = 30" stroke

Exhaust valve setting	Open; piston 1"	out;	lead	5.625"
	Close: piston 14.5"	in;	lag	8.875"
Mixture valve setting	Open; piston 22.75"	in;	lead	0.625"
	Close; piston 3.875"	out;	lag	2.75"
Gas valve setting	Open; piston 20.5"	in;	lag	2.875"
	Close; piston 6.25"	out;	early	0.375"

Compression pressure: 120 lb.

Compression pressure ratio $\left(\frac{C. P. + 15}{15}\right) = 9.0$

Volumetric efficiency: 0.876

Effective piston displacement: (Spec. P. D. × V. E.) = 6.88

Clearance volume ratio $\left(\frac{1.3}{\sqrt{C. P. \text{ ratio}}}\right) = 5.4$

Clearance volume $\left(\frac{E. P. D.}{C. V. R. - 1}\right) = 1.563$ cu. ft.

Charge volume: 8.443 cu. ft.

Improvements obtained: power per impulse, 9 per cent; consumption, 10 per cent.

ROYAL SOCIETY OF ARTS

Journal, vol. 62, nos. 3189, 3190, 3191, January 2, 9 and 16, 1914, London

THE MEASUREMENT OF STRESSES IN MATERIALS AND STRUCTURES, E. J. Coker (30 pp. 41 figs. *dtA*). A somewhat popular, but very interesting presentation of the main problems and methods of measurement of stresses in materials and structures, forming the subject of three Cantor lectures delivered by the author in December 1913. The part referring to the optical methods of measuring stresses is reported in the Foreign Review section, from an article by the same author appearing in another publication.

FOREIGN REVIEW AND REVIEW OF THE PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

An inquiry has lately been received as to the right of reprinting an abstract from the Foreign Review. In accordance with the policy of the Society, all matter published in The Journal is free for reprinting, and anything tending to extend the usefulness of the Survey is heartily welcomed. As a matter of fact, both American and British engineering papers reprint from time to time articles from The Journal.

THIS MONTH'S ARTICLES

The first section, Air and Gas Engineering and Air Conditioning, contains a detailed abstract of an article on preventing the formation of a mist in factory rooms, and the heating system used in this connection; a valuable discussion of the oscillation pyknometer, an acoustic instrument for measuring the density of gases and liquids, and data of tests on the explosion points of various mixtures of natural gas and air. In the next two sections are given a description of a large heating system where a number of buildings are heated by exhaust heat from gas engines, and some data of tests of a hydraulic air compressor. Under the heading Internal-Combustion Engineering will be found an illustrated description of the new type Delaunay-Belleville carbureter, of the De-Fontaine revolving grate gas producer, and on various methods of governing the water injection in hot bulb engines. The Shop Processes section comprises the first installment of an article on the investigation of the autogenous processes of cutting metals, and on cast-iron founding. The section on Steam Engineering is of particular interest. It includes an investigation of the influence that the temperature of superheated steam exercises on the steam consumption of the engine; on trouble from unclean steam in modern high-duty boilers, and how to avoid it; and on natural steam in Tuscany. The next section contains some data on the influence of arsenic on the strength of rail steel.

A comparatively large number of abstracts are made this month from the proceedings of various engineering societies in addition to those mentioned in connection with the Foreign Review section. The following subjects have been considered: compressibility of ice; use of peat powder as fuel for locomotives; advisability and conditions of using mixtures of coal tar and creosote for wood preservation; tests on concrete columns reinforced with a spiral of steel; how pores in hollow brasses may be closed; heat economies in sugar factories, and the influence of using multiple effects, vapor heaters and vapor pans; air brake performances in actual practice and causes of imperfect operation; nature of steel from the physico-mathematical point of view; trouble from corrosion in tramp steamer boilers, and use of calcinated soda to prevent formation of scale when using sea water; electric train lighting; modern methods of welding; absorption of oxygen by coal; reversing air currents in coal mines and the mechanical structure involved; steel passenger car design; electrical conductivity under varying conditions of cross ties treated with creosote; preservation of wood (in particular use of sugar); testing low-head water turbines (with data on the Holyoke testing plant.)

FOREIGN REVIEW

Air and Gas Engineering, Air Conditioning

EXPLOSION POINTS OF NATURAL GAS MIXTURES (*Explosionsgrenzen von Naturgasgemischen*, Z. Z. Biluchowski and Z. Lahocinski. *Petroleum*, vol. 9, no. 9, p. 605, February 4, 1914. 2 pp. *c*). The rapid development of the natural gas industry as well as the extended use of natural gas for heating and lighting purposes prompted the author to undertake an investigation of the explosion points of mixtures of natural gas with air.

The explosion points of such mixtures depend usually upon the temperature of the explosion exciter and the gas mixture, on the thermal properties of the gases and their products of combustion and especially on the ratio of mixture of the gas with air. This matter has not hitherto been fully investigated, at least not with regard to the Galizian natural gas with which the authors made their tests. The testing arrangement was as follows:

A gasometer of about 20 liters capacity was provided with an Orsat apparatus and a Hempel explosion pipette in such a manner that the gas mixture could be investigated immediately previous to the explosion. The pipette contained about 150 cm. (9.15 cu. in.), and was provided with platinum electrodes separated from each other at a distance of 2 mm. (0.08 in.), the explosion being produced by an electric spark from a small induction coil excited by alternating current. The natural gas used for the test was taken from the main pipes of a Galizian distributing system, and at the time of the test contained 40 per cent air and had a specific weight of 0.870. The tests were made with air mixtures from 40 per cent up, because previous tests with other kinds of gas have shown that investigations of mixtures containing less than 40 per cent did not present any interest. For the production of benzine, the lowest gasolene obtained from Bitkower crude oil has been used, with specific weight of 0.622 at 15 deg. cent. (59 deg. fahr.). This benzine was selected on the ground of previous investigations because the ability to form explosive mixtures belongs preëminently to the lightest oils, and further, because the properties of these products of fractional distillation approach very nearly to those of pentane with which similar experiments have previously been made. The desired mixtures have been prepared by evaporating small amounts of benzine in a separate gasometer and by passing the vapors into the gasometers with the Hempel explosion pipette. In this manner they could prepare mixtures with the desired content of air.

In order better to determine the influence of the test conditions, the authors have also determined the explosion limits of methane, which was produced in the usual manner, washed in concentrated sulphuric acid and of a specific weight of 0.561 (air = 1). Table 1 exhibits data of the present test as well as those of former tests by Bunte, Eitner and Trautwein. The average temperature at which experiments in the present series have been made was 20 deg. cent. (68 deg. fahr.). From this table it appears that, although according to previous investigations of Dr. Hausmann and Dr. Gruszkiewicz, natural gas approaches methane in its

general properties, it possesses the closest limits of explosibility, while methane has the widest limits, which confirms, by the way, the observations of Eitner that the explosibility of a gas is materially affected even by comparatively unimportant chemical influences. Contrary to expectations, the explosion limits of methane coincide with those of gasolene. These tests seem to show that the utilization of natural gas, in so far as possibilities of explosions are concerned, does not involve any particular danger.

TABLE 1 EXPLOSION POINTS OF NATURAL GAS-AIR MIXTURES

Kind of Gas	Percentage of Combustible Gas in the Mixture			Explosion Limits	
	No Explosion	Explosion Region	No Explosion	Lower	Upper
Methane *	6.0	6.2 to 12.7	12.9	6.1	12.8
Methane.....	3.6	3.8 to 8.9	9.1	3.7	9.0
Pentane *.....	2.3	2.5 to 4.8	5.0	2.4	4.9
Benzine *.....	2.3	2.5 to 4.8	5.0	2.4	4.9
Bitkower gasoline.....	2.9	2.94 to 8.0	8.2	2.9	8.1
Natural gas....	7.5	7.6 to 9.0	9.2	7.55	9.1

* Taken from the experiments of Eitner and Bunte.

THE TECHNICAL IMPORTANCE OF MEANS FOR ELIMINATING STEAM FROM THE ATMOSPHERE IN FACTORIES (*Die technische Bedeutung von Entnebelungsanlagen*, Oscar Gerold. *Dinglers polytechnisches Journal*, vol. 329, no. 6, p. 86, February 7, 1914. 4½ pp., 4 figs. *dg*). During cold seasons in rooms in which a large amount of water vapor is generated, for example, in textile mills, dye works and paper factories, fog or mist is formed in the air causing annoyance and trouble: such a mist is formed whenever the air is supersaturated with water, i. e. whenever the air at the temperature prevailing in the room is unable to hold in purely gaseous suspension the water vapor generated. This is due to the fact that the air is able to take up at a definite temperature only a certain maximum amount of water vapor, and still remain clear and transparent; but whenever the amount of water vapor present exceeds that maximum for the given temperature, the surplus of the water appears to the eye as a fog or mist. In order, therefore, to prevent the formation of fog in the room, either of the following two ways, or both simultaneously, may be resorted to: viz. either the amount of the water vapor generated per unit volume of air present may be reduced or the temperature of the air raised. The latter can be done only up to a certain limit since the presence of workmen in the room makes it impossible to raise the temperature indefinitely.

In order properly to design the apparatus for the prevention of fog formation in the rooms, one must know first the exact amount of vapor generated in the room and, second, must provide means for controlling the temperature of the room. As regards the formation of vapor one has to consider the following: the distinction between evaporation and vaporization; amount of water evaporated as determined from the area of the surface of the water; temperature of the liquid and motion of the air layer in contact with the water; the weight of the water evaporated per square meter of surface may be determined by the following formula:

$$G = \frac{ck\ (S_1 - S_2)}{B}$$

where G is the weight of the liquid evaporated per hour per square meter of the free surface in kilograms; c is a constant depending upon the properties of the liquid under evaporation, its saturation, etc.; k is a factor which expresses the influence of the velocity in the layer of air in contact with the liquid: S_1 is the pressure of the steam corresponding to the temperature of the liquid under evaporation; S_2 is the pressure in the air above it, containing water vapor, and B

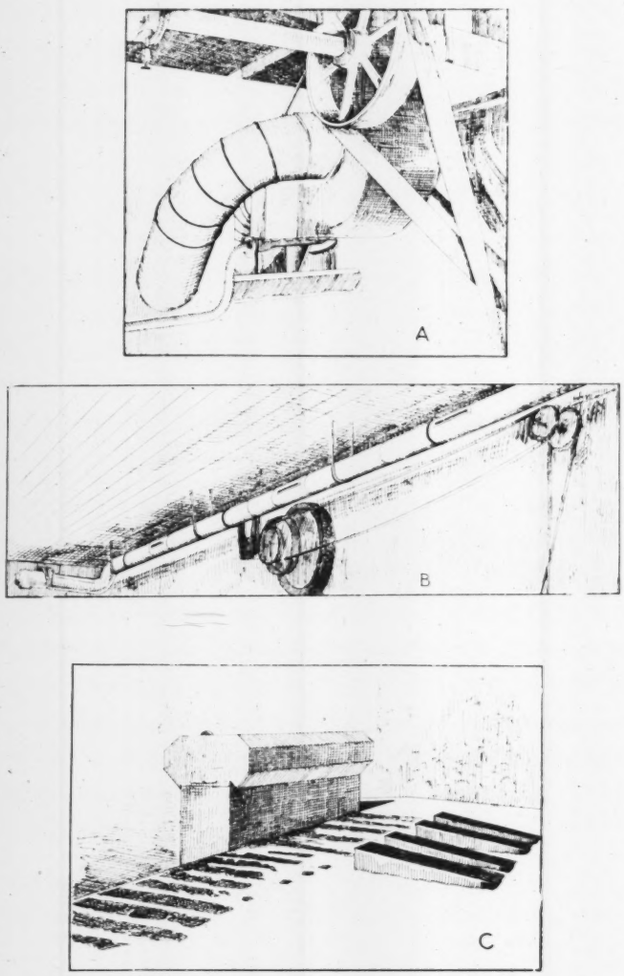


FIG. 1 APPARATUS FOR HEATING FACTORY ROOMS AND ELIMINATING MIST FROM THE ATMOSPHERE

is the barometric pressure in the room (with all the pressures expressed in units of mercury).

After the amount of the liquid transferred into the atmosphere per unit of time is determined with due respect to the external temperature in summer and winter, and under an assumption of a certain internal temperature, the amount of air must be sufficient to take up all the liquid evaporated in a manner such that there should occur no complete saturation. It is, however, important that there should be not only no complete saturation but that the amount of vapor in the air should not be even near the complete saturation point because not only mist in the air, but even the presence of

moisture closely approaching complete saturation point injuriously affects the health of the workmen. If, for example, at a temperature of 20 deg. cent. (68 deg. fahr.) the air is saturated with water vapor to say 95 percent, the human body can no longer evaporate moisture outward, which produces harmful disturbances in the mechanism of exchange of materials in the body and causes an unpleasant feeling which affects the health, efficiency and attention of the workmen. A man can remain for many hours in a room at a temperature of 40 deg. cent. (104 deg. fahr.) if the air is dry, because the body is then sufficiently cooled by the process of perspiration, while in a room with the air saturated with steam at a temperature of 20 deg. cent. (68 deg. fahr.) where the evolution of sweating is absent, the men will very rapidly begin to experience an unpleasant sensation. It is therefore advisable not to permit the humidity of the air to rise above 80 per cent of the saturation limit.

The third magnitude which has to be taken into consideration in the design of the humidifying plant is the amount of heat required to dry the air up to the point at which it can take up all the moisture present. This can be done in the usual manner, but attention must be paid to whether a special heating system is provided for the rooms where the humidifying processes are to be carried out and whether this system of heating can deliver the temperature required in the rooms for this purpose; or whether the heating is provided by means of air driven in by the apparatus used for the humidification itself. In any case it is advisable to supply the air into the rooms under pressure so as to furnish the room with a pressure somewhat above the atmospheric, and by this means to prevent the flow of air into the room through windows, doors and cracks in the walls, as such an influx of air might affect the results. For the proper working of the dehumidifying plant, much depends on the design of the heating apparatus. Fig. A shows a type installed in a paper factory with which it has been possible to effect an extraordinary saving of space, which is of importance since no special room is provided for the installation of the heating apparatus, which has to be placed flat on the wall or ceiling of the room. It shows a low pressure fan with the heating apparatus built onto it, seen in the illustration in the opening left uncovered for this purpose. The fan sucks the air in through a quarter bend from the atmosphere and forces it through the heating apparatus into the distributing piping system. The piping performs the duty of distributing the heat uniformly in the room and, as far as possible, should bring it to the level of the floor as warm feet and cool heads are the most desirable conditions from the view point of efficiency and health of the workmen. The pipes can usually be placed so that they would be in no one's way, in the ceiling or openings of the steel frame, while the outlets for the warm air must be regularly distributed so as to prevent the outflow of the warm air in the form of a violent draft which might become unpleasant.

Fig. B shows the distribution system over a paper-making machine used for the manufacture of a special kind of paper. The warm air passes through an exhaust chamber in thin multiple layers due to the presence in the box of an adjustable link. The air flows from under the cover and distributes itself over the entire area in a manner such that the warm air passes in between the cover and the water vapor and rises upwards owing to its specific weight. By this means, the ceiling is kept warm and the water vapor is taken up to where the conditions for so doing are most advantageous. The links are built in so that the entire movement of the air which takes place in the ceiling of the machine room is directed toward the air shaft and passes into an exhaust.

Fig. C shows a view of this exhaust shaft as seen from the roof. In order to prevent a lateral formation of mist due to the presence of walls and windows, the pipes are provided with narrow slots which permit of the escape of the warm air sidewise. The heating arrangement of the dehumidifying plant shown in this illustration is easily adjusted; for example, the temperature in the room can be regulated from any desired place to practically any desired level by moving a simple pointer of a special thermostat.

In the design of all such apparatus must be considered the heat losses due to the flow of the air through the heating pipes at the lowest outside temperature. These calculations do not, however, differ from those usually required for air heating installations and therefore are not reproduced here.

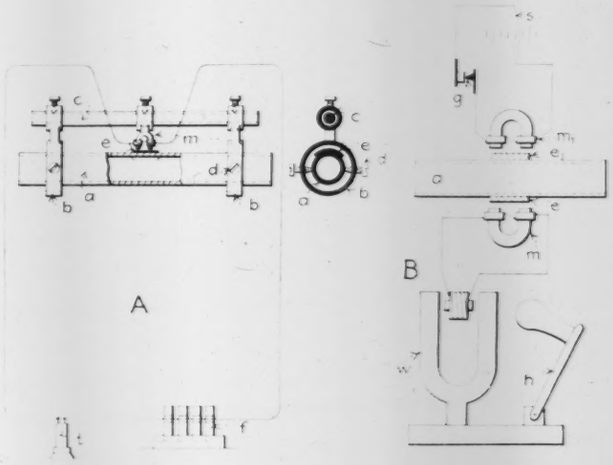


Fig. 2 Oscillation Pyknometer for Measuring the Density of Fluids

The Oscillation Pyknometer, an Acoustic Apparatus for Measuring the Density of Gases and Liquids (*Das Schwingungspyknometer, ein akustischer Apparat zur Dichtmessung von Gasen und Flüssigkeiten*, A. Kalächne. *Dinglers polytechnisches Journal*, vol. 329, no. 6, p. 81, February 7, 1914. 3 pp., 2 figs. *d.*). In various branches of engineering, there is need of an apparatus for making rapid determinations of the density of gases and liquids. While this is not so difficult for liquids, in the case of gases where the densities are very slight, while the technical processes often require a great precision of measurements, the problem is a rather complicated one. It is for this reason that the apparatus described in the present article deserves particular attention. The inventor of the apparatus calls it an *oscillation pyknometer* and it is really an acoustic apparatus for measuring the density of gases and liquids. It appears to be particularly convenient for measuring densities of gases in small enclosed spaces, such as glass vessels, gasometers, cylinders of gas engines, etc., and has the further advantage of permitting the reading of indications at a distance by means of an electromagnetic transmitter.

It may also be used for measuring high densities of gases

at high pressures, in which case, however, it has to be designed in a somewhat different manner. This process is based on the fact that when a solid body moves in a fluid, whether gas or liquid, it carries with it particles of that fluid and thereby suffers a certain apparent increase in mass. If the motion of the body is of an oscillatory character, the apparent increase of its mass may be observed from the change of its natural period of vibration, the frequency of the oscillation of the body increasing in a certain proportion to the increase of density of the medium in which the oscillation occurs. In the present process, the elastic body which performs the oscillatory motions is of the nature of a sounding element, such as a string; it is immersed in the medium under investigation, and the variation of its natural period of vibration as compared with its natural period of vibration when not under the influence of the given medium (when in a vacuum or in a normal medium) is measured, and from the variation of the frequency, the density of the fluid is immediately obtained if the apparatus has been properly and empirically calibrated from observations made on mediums of known densities.

If the variations in the frequency are small as compared with the natural frequency itself, and amount to a few oscillations per second with a natural period of vibrations of several hundred oscillations per second, then the variations are proportional to the corresponding differences in density, which makes the calibration of the apparatus and the reading of the densities a simple matter. This applies, for example, to the case when gas densities are measured in the neighborhood of atmospheric pressure or at pressures not greatly varying from it. In order to measure gas densities by this process, the sounding element must be very light and possess a large surface so that the gas mass carried away by it be as large as possible. In the apparatus as constructed by the inventor it is made of aluminum and has the shape of a pipe with thin walls surrounded by gases inside and out, forming transversal oscillations similar to those of a bar rigidly held at two points. Glass which has a specific weight somewhat below that of aluminum is also suitable, while instead of a tube-shaped body, a plate or bell-shaped body may be also used.

The article describes in detail the construction of the apparatus as well as the devices for measuring the natural periods of oscillation, an important element in the present case.

These are shown in Figs. A and B: *a* is the sounding element, a hollow cylinder which vibrates in its fundamental tone, like a cylindrical bar with free ends. To make this possible, the tube is supported by two pairs of pointed screws *dd* at the two knots of motion, the screws being supported in ring-shaped holders *bb*, movable along a supporting bar *c*, so that they may be located at just the right knots of motion. The bar *c* carries also the apparatus used for the excitation of oscillation and for the measurement of the frequency, both of which may be done in several ways, either by exciting vibrations mechanically and comparing them acoustically with known products of normal sounding bodies, such as a tuning fork, or with a frequency meter, e. g. the Frahm frequency meter with oscillating pipes, or the sounding element may be excited to resonant oscillations by a periodically acting body having similar or perfectly equal oscillations of known frequency. When the exciting frequency and the natural period of oscillations of the sounding body are equal, the largest frequency (resonance) takes place so that from the resonant curve may be derived also the value of the natural period of oscillations. The first form of measurements is shown in Fig. A with the striking hammer omitted, the second system in Fig. B; the transmission of oscillation of the measuring devices in both cases and the excitation of the sounding body in the second case are effected electromagnetically on the telephone principle, the sounding body carrying at the point of maximum *amplitude*, one (Fig. A) and two (Fig. B) iron pieces *e* and e_1, closely opposite to which are located the telephone magnets *m* and m_1 fixed independently of the sounding body. In Fig. B, the coils of the exciting magnets *m* are energized by alternating current produced by the tuning fork *w* with a coil and iron core between its prongs.

This tuning fork must be of the type which permits regulation of the tune, such as the Koenig or Neesen type, but of course any other source of alternating current may be used if its frequency can be maintained sufficiently constant and measured with adequate precision, this being of great importance in the present case. The vibrations of the sounding element produce in the coils of the magnet in the measuring circuit *m* in Fig. A and m_1 in Fig. B an alternating current of the frequency of the oscillating sounding body which may be measured either directly by including in the circuit a proper device, such as the telephone *t* and frequency meter *f*, but more conveniently by determining the amperage of the alternating current generated and the excitation frequency which gives that maximum amperage obtained (Fig. B) by means of a string galvanometer *s* the current being rectified at *g* where a crystal rectifier similar to a crystal detector used in wireless telegraphy may be inserted.

The precision of measurements and of the oscillation pyknometer depends in the first instance on the ratio of the mass of the sounding body to that of the gas and liquid carried away by it, and in the second place on the sensitiveness of the auxiliary apparatus, oscillation exciters and frequency meters, and so far it has not been possible to establish the exact limits for the precision of the apparatus, the relative sensitivity of the apparatus being apparently greater for denser gases than for lighter ones, but the sensitivity of the apparatus may be materially increased by using a lighter oscillation element. The difficulties of construction are much less when denser fluids, such as compressed gases or liquids, have to be measured.

Heating

Utilization of Exhaust Heat from Gas Engines for the Heating of Buildings (*Abwärmeverwertung von Gasmaschinen für Fernheizung, Stahl und Eisen*, vol. 34, no. 8, p. 318, February 19, 1914. 3 pp., 3 figs. *d*). In the plant of the Adolf Emil Works, the administration office building, the employees' club and the houses where the employees live are heated throughout by water, which is heated by the exhaust gases from the large gas engines.

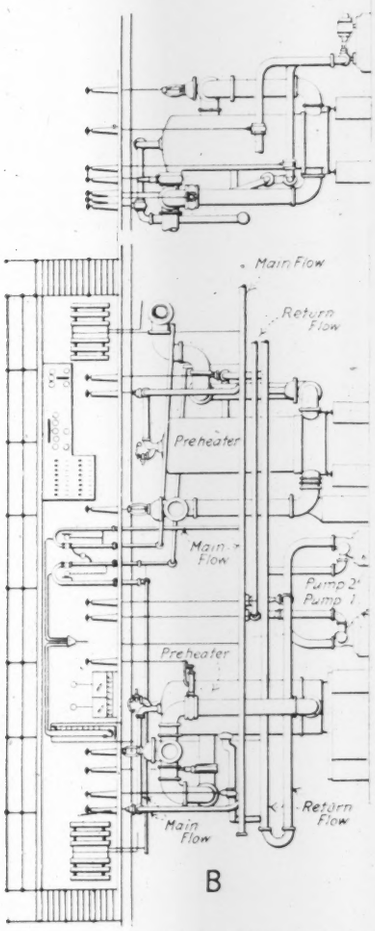
In addition to the above-mentioned buildings, the gas central station and automobile garages are fed by heat from the same station, and several other smaller plants, as indicated in Fig. 3 A. The largest heat consumption per hour of all these buildings, at outside temperature of—20 deg. cent. (4 deg. fahr.), is approximately 3¼ millions WE (12,870,000 B.t.u.) for the delivery of which in the gas central station four preheaters are provided with an hourly output

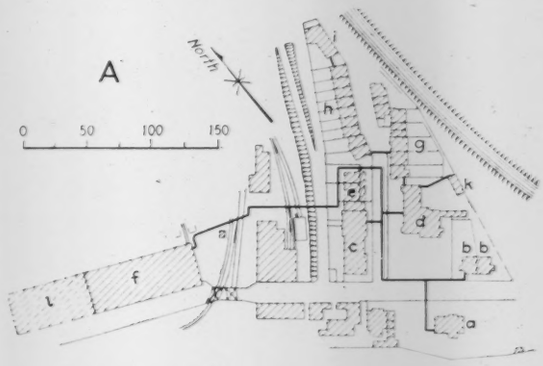
of 800,000 to 1,000,000 WE (3,168,000 to 3,960,000 B.t.u.), each heated by the exhaust gases of the large gas engines.

These preheaters are designed as tubular boilers with rolled-in tubes and cast-iron jackets, the water playing around the tubes while the gases pass through the tubes. To produce an eddy motion in the exhaust gases and so raise the amount of heat which they give up, sheets, with spiral windings, are built-in in the tubes. The most important property of hot water heating, the common heat regulation, is secured by a corresponding regulation of the temperature of the heating gases in large gas engines. Cold water is injected into the exhaust gases in the usual manner shortly before their exit from the cylinder, and the amount of this injection is regulated. The temperature of the mixture of steam and gas may therefore be regulated to any desired amount from 100 to 600 deg. cent. (212 to 1112 deg. fahr.).

To determine the temperature in the exhaust in front of the preheaters, electric distance thermometers are installed, connected with similar thermometers showing the temperature of the hot water and various room temperatures in the colony of buildings served by the plant. In addition to that, the distance thermometers are connected with an alarm device in such a manner that if the temperature of the hot water exceeds a certain amount, the device lights up a special little lamp and rings a signal bell. This device is independently installed for each preheater, but all the distance thermometers measuring room temperatures, have a common indicating apparatus where a switching device for cutting-in any separate thermometer is provided. Safety valves are provided to insure the preheater against explosions which might take place owing to carelessly closed valves or failure of the pumps. The circulation of hot water in the system is taken care of by a centrifugal pump direct connected to a direct-current electric motor. A second pump serves as a reserve. The entire arrangement of the pumps and preheating boilers, as well as the general scheme of the electric connections is indicated in Fig. B. The pumps and preheaters are installed in the basement of the gas central station, but the gate valves and starting devices may be actuated from the machine room on the next floor. As the various buildings are operated in series, one after another, the starters are designed in a manner such that they regulate the speed of rotation so as to regulate also the flow of water to the desired dynamic pressure of the pumps on the basis of the indications of the hydrometer, since in large plants a direct regulation by pressure cut-off valve or shunt piping with an adjustable slide valve is difficult to design and cannot be operated without considerable power losses. The amount of water can be easily determined from the readings of the ammeter, voltmeter and hydrometer when the efficiency curves of the motor and pump are known.

As shown in Fig. B, the hot water is driven by the pump





a Director's House; *b* Dwelling Houses of the Engineers; *c* Administration Building; *d* Employees' Casino; *e* Supplementary Administration Building; *f* Gas Central Station; *g* Eastern Section of the Employees' Colony; *h* Western Section of Employees' Colony; *i* Hall; *k* Automobile Garages; *l* Extension of the Gas Central Station.

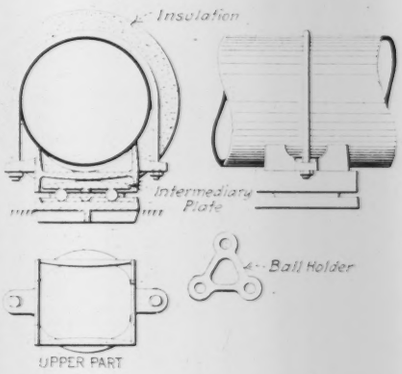


Fig. 3 German Heating System Operated with Exhaust Heat from Gas Engines

through the preheater, and, after being preheated, goes into the main pipe from which the pipe for heating the gas central station branches off. Further, as shown in Fig. A, the main pipe leads to a branch pipe of 850 mm. free diameter (34 in.), in which are also located the electric cables for light and power transmission as well as the distant thermometer wires, all of these being placed in cast-iron conduits. On the pipe corners as well as at every 20 m. to 25 m. (say 65 ft. to 98 ft.) are placed inspection shafts and manholes. The main piping, branch piping and distributing piping are everywhere autogenously welded, which was found to be very convenient when the welds are made in a workmanlike manner. All the distant piping rests on ball bearings which admit a displacement of 90 mm. (36 in.) for pipe expansion. The compensating displacement of the bearings are dimensioned accordingly. As shown in Fig. C, the ball bearings setting consists of a crown plate, three balls kept in position in a movable plate with three holes, and an intermediate plate with the uniform transmission of pressure on one hand to the bearings, and on the other hand to the upper part of the setting. As the initial designer of the plant had to consider the possible trouble in the operation of preheaters, exhaust gas piping, etc., as a reserve for preventing disturbances in the operation of the heating system, in the casino, ten cast-iron sectional boilers with a total heating surface of 356 qm. (3831 sq. ft.) have been installed where there is also a reserve pump for water circulation.

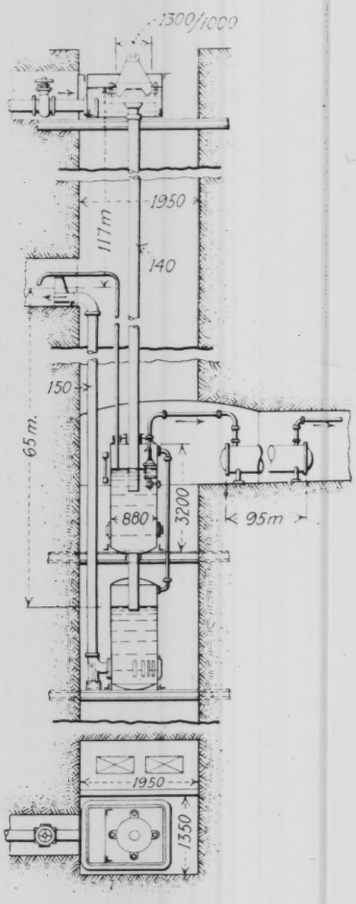


Fig. 4 Hydraulic Air Compressor Plant

The article gives some further details of the installation, but does not contain any information as to costs or efficiency nor does it refer to any tests of the plant.

Hydraulics

Novelties in Hydraulic Compressor Design (*Neuerungen an Hydrokompressoren*, Heirich. *Dinglers polytechnisches Journal*, vol. 329, no. 7, p. 100, February 14, 1914. 2 pp., 1 fig. *d*). The article gives some rather incomplete data on a hydrocompressor installed in a German mine. Fig. 4 shows the general construction of this compressor which was built about four years ago and tested in 1910 when the data given in Table 2 were obtained. This table shows among other things that the determination of the useful effects of the compressor in accordance with the adiabatic formula has no sense and leads to results materially more favorable than those actually obtained.

The hydrocompressor compresses the air not adiabatically, like the mechanical compressor, but isothermally, as is proved by thermometric measurements. The suction apparatus takes in the air in the form of jets enclosed by streams of water and thoroughly mixes it with the water so that it is finally in the form of numberless bubbles surrounded by water which produces perfect cooling. Owing to this fact,

TABLE 2 DATA OF TESTS OF A HYDRAULIC AIR COMPRESSOR

Head 117 m (say 384 ft.); air compression 6.2 atmospheres gage

Quantity of Water, Liters per Sec.	Water Power, H.p.	Quantity of Air, Liters per Sec.	Compression Output		Efficiency	
			Isothermal	Adiabatic	Isothermal	Adiabatic
18.0	28.4	7.2	18.9	25.6	0.66	0.90
30.5	47.6	10.8	28.5	38.5	0.60	0.81
32.2	50.2	11.2	29.5	40.0	0.59	0.80
35.7	55.6	11.4	29.9	40.4	0.54	0.73

the power required to effect this perfect isothermal compression is considerably less than when the compression takes place adiabatically, i. e., with the simultaneous heating of the air. The compressor shown in the drawing was investigated last June by some engineers who have found a number of defects in the construction of the air suction apparatus and separator. The required alterations in both are said to have been made and the efficiency materially improved thereby. The article does not fully state, however, what alterations have been made or how.

In order to be able to measure the air sucked in by means of an anemometer on the suction head of the apparatus, an air-tight sheet-iron funnel has been built in with an upper cylindrical section with a diameter of 250 mm. (say 10 in.).

The water is measured by filling the outlet tank, and calculation has shown volumetric efficiency of 90 per cent. In order to improve the separation of the air, under the air separator a second one has been built in, correspondingly prolonging the ascending pipe and adjusting the air separation in a manner such that the compressor works constantly with the pressure of 6.5 atmospheres gage. For this purpose, in the air outlet pipe behind the air separator, a throttling valve has been built in, arranged in such a manner that the controlling manometer in front of this valve shows a constant air pressure of 6.5 atmospheres. To the throttle

valve was connected an outlet air pipe for measuring the outgoing air; numerous measurements show that the outgoing volume of air is about 90 per cent of the incoming air as measured at the head of the suction system, 10 per cent having evidently been lost through joints which were not air tight. The output efficiency, or the ratio of the air delivered to that actually taken in by suction is therefore 90 per cent and the mechanical efficiency, i. e. the ratio of the actually useful output to the theoretical water output is $0.90 \times 0.90 = 81$ per cent. For controlling the anemometer measurements, a measurement by means of a calibrated tank has been made, for which the air collector of 350 mm (14 in.) diameter and 95 mm (3.8 in.) long served as a calibrating tank. This measurement has shown a small difference of 0.04 cbm min. as against the anemometric measurement, which may be ascribed to lack of air-tight connection in the air collector with its 32 pipes. Tests have shown however that by means of autogenous welding, absolutely air-tight joints in the collector may be obtained, in which case the efficiency of the compressor would be raised to 90 per cent.

Internal-Combustion Engineering

Governing the Water Injection in Hot Bulb-Engines (*Regulierung der Wassereinspritzung bei Glühkopfmotoren*, A. Dussmann. *Der Motorwagen*, vol. 17, no. 5, p. 93, February 20, 1914. 3 pp., 4 figs. *dp*). In crude oil engines with hot bulb ignition, when run at high duty, some arrangement must be made for maintaining the hot bulb at a constant temperature. At low loads, water injection, which is the usual means of regulating the temperature, is not necessary, but has to be used when running at high load. This involves very undesirable complications, not so much because the water attacks the cylinder walls as because it is difficult to regulate the water injection, especially in the case of small units or units used in farm machinery, where an experienced engineer is not available, and, as a matter of fact, even an experienced operator has not always been able to regulate the injection in an absolutely proper manner.

A device which would make this adjustment automatic, if sufficiently reliable and cheap, would materially extend the use of this type of prime movers. The author describes several methods proposed to solve this problem; the simplest way would be to combine a fuel pump with the water pump and thus regulate the injection (Fig. A). Both pump plungers are driven from a common cam. The lever *a* actuates the suction valves of both pumps in such a manner that at the suction stroke they are lifted and at pressure stroke closed by springs. The regulator, driven by helical wheels, displaces the fulerums of the lever *b* in such a way that the suction valve, in accordance with the load on the engine, may remain open for a shorter or longer time during the pressure stroke, so that the liquid which has not been used may flow back into the suction space. By means of this construction it is possible to govern, by one governor, both the fuel and water injection. The author claims to have made extensive experiments with such a pump arrangement and to have established the fact that this system of government is of only small use and does not eliminate in the least the necessity of regulation by hand. For various loads, the quantity of water to be injected is not in constant ratio to the quantity of fuel and therefore the water pump and fuel pump must be governed by two independent governors; such an arrangement would make a small unit far too expensive.

Another solution lies in the utilization of temperature

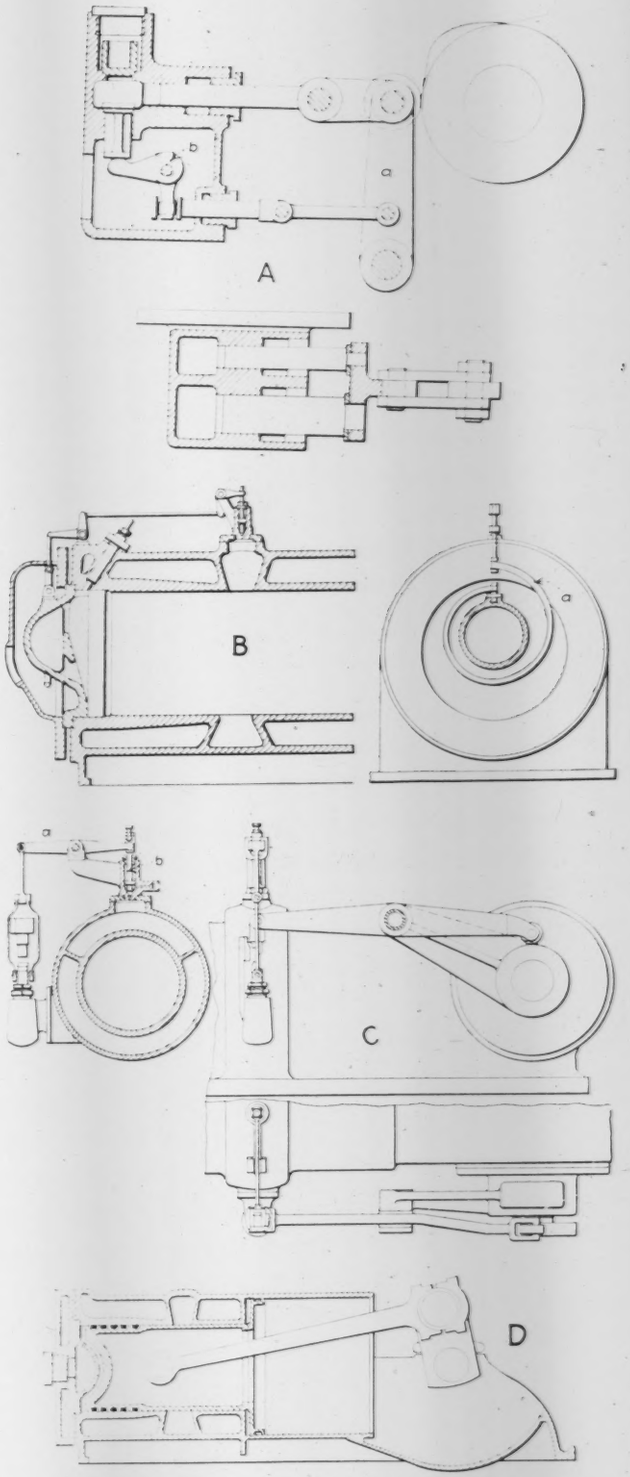


Fig. 5 Various Systems of Governing Water Injection in Hot Bulb Engines

exchange of the hot bulb itself. Theoretically this appears to be correct, since all that the water injection has to do

is to regulate the temperature of the bulb. Fig. B shows how this is done. A ring *a* expands when the bulb becomes too hot, and through its expansion raises the stem of the needle valve and thereby increases the cross-section of the water passage. There are also used pendulum governors especially adaptable in this case because the hot bulb engine does not require great precision of operation. When such a governor is used, the fuel admission is governed on the hit-or-miss principle. During the idle stroke the water injection is not required, since no combustion takes place, and there can be no rise in temperature of the bulb; the elimination of the water injection during the idle stroke is secured by connecting the water inlet valve with the pump plunger. Fig. C shows a very simple embodiment of this principle. The fuel pump is located in the neighborhood of the injection nozzle in order that the injection should occur with pre-

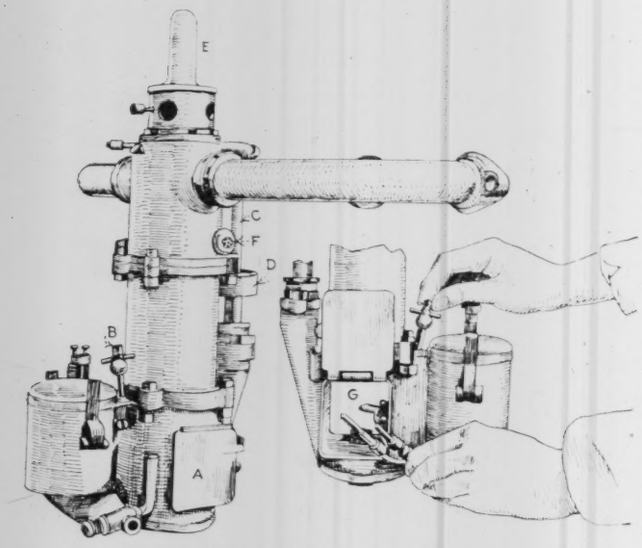


Fig. 6 Delaunay-Belleville Carbureter

cision. Long piping leads to an after-burning of the charge due to the expansion of the pipe walls during the pressure stroke and their contraction after the end of the stroke. If it is desired to drive the fuel pump in a simple manner, this may be achieved only by using a long lever which must be of generous dimensions in order to prevent the rise of spring action. In calculating the dimensions of the lever, the plunger must be assumed to work at about 100 atmospheres. The fulcrum of the lever as shown in Fig. C may be secured in the simplest way by means of an arm fixed on the gear bearing. The lever *a* is driven from the plunger by means of a connecting rod, raises at an ignition the valve *b* and makes water injection possible. If, at the higher speed, the knife is so accelerated by the rise of *c* that it no longer comes in contact with the knife of the plunger, the stroke remains idle and the valve *b* is not opened. Above the valve is located an adjusting screw which permits of the adjustment of the stroke. The author tested this construction on a 4 and 15 h.p. engine and found that it works very well. Regulation by hand was no longer necessary, either when the load was taken off the brake entirely or the brake loaded to maximum. The only disadvantage of this system is the noise produced.

If larger machines are used, in which more exact governing is required, the system of the crude oil engine must be changed and in place of the low pressure engine, a middle pressure engine has to be used. The compression pressure must be raised to 18 to 20 atmospheres, and the fuel similar to the practice in Diesel engines, must be injected only a little while before the dead point. The hot bulb cannot then be installed in the usual manner, since at high pressure it would easily break; it has to be provided with openings as shown in Fig. D, so that the walls of the hot bulb should no longer be subjected to pressure, nor affected by unequal expansion.

Such an engine does not require water injection at all, and no preignition can occur in it since the fuel is admitted to the combustion chamber only when the explosion is apt to take place. The combustion process in such an engine is, however, entirely dissimilar to that of the usual hot bulb engine, and while in the latter the desired gasification of the fuel is effected by the presence of the glowing bulb, in the middle pressure engine it approaches more nearly that of the Diesel engine, with the combustion taking place on the introduction of a finely divided fuel.

The New 25-30 H.P. Delaunay-Belleville Car (*La nouvelle 25-30 chevaux Delaunay-Belleville*. E. Pepinster. *Omnia*, vol. 9, nos. 425-428, February 21, 1914. 4 pp., 6 figs. *d*).

The carbureter in the new 25 to 30-h.p. Delauney-Belleville car is of unusual construction and dimensions. While in the standard types of car the carbureters are becoming smaller and smaller, the new Delauney-Belleville carbureter is large (larger than all its predecessors). This is due to the fact that the standard carbureter is expected to adapt itself to all kinds of engines by means of some adjustment which varies for each individual case. It must therefore satisfactorily meet such requirements as are common to all kinds of engines and the number of such requirements is naturally smaller than that of a single type of engine. On the other hand, the Delauney-Belleville carbureter is made to work with the Delauney-Belleville engine only, but has to satisfy all the conditions presented by this engine. It is therefore both more complicated and more voluminous than the standard carbureter, but provides an incomparably greater collaboration between the engine and the carbureter. The principle of its construction is as follows:

A normal-run spraying nozzle creates a rich mixture which the supplementary air adjusts more or less in accordance with the more or less energetic suction of the engine. The slow-down spraying nozzle, which is merely an auxiliary carbureter, feeds the engine at low speed. The engine is a six cylinder and the normal speed carbureter is made in two units, each unit taking care of three cylinders and having its normal speed spraying nozzles and diffusors independent for each group. On the contrary, the auxiliary carbureter, as well as the supplementary air valve, are common to both groups, and with one-sixth of the heat generating circulation around the diffusors, the slow-down carbureter and the supplementary air piping, one can easily see why this apparatus works in about the same manner as a small gas factory. The supplementary air reaches the spraying nozzle by two tubes which pass through the jacket of the engine and collect air preheated by convection around the exhaust gas manifold. The carbureter is not therefore in danger of troubles due to lack of preheating, while on the other

hand, precautions have been taken to prevent excess of preheating. To do this it is necessary only to open the lateral seams and close the spraying nozzle chambers, after which air is taken directly from the atmosphere.

The installation and regulation of the new carbureter is both simple and successful. The slow down is regulated by a large knurled button concentrical to the auxiliary carbureter. As to the two normal-speed spraying nozzles, they are twin connected by means of a very original device. The two nozzles are simply placed on their seats and maintained in place by a little oscillating finger. When this finger presses on the common seat of the spraying nozzle they become stationary, but when the finger lifts, they can both be moved simultaneously. The efficiency of this carbureter is excellent owing to the simple paths of the gas and to the division between the two groups of cylinders. The suction of the motor is not opposed by any counteracting partial vacuum and can be fed with the same facility at high speeds as at low speeds. In addition, the supplementary air enters the piping immediately behind the narrow zone of the diffusor cones, i.e. way in front of the valves, which arrangement is claimed to ensure the absolute homogeneity of the mixture. The car possesses several other interesting details such as a new type of gear drive, which cannot, however, be described here owing to lack of space.

De-Fontaine Revolving Grate Gas Producer (*Drehrostgenerator System de Fontaine*, Gwosdz. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 7, p. 78, February 13, 1914. 1 p., 2 figs. *d*). The technical and commercial success of the Kerpely rotary grate gas producer brought about a number of designs tending to improve or displace that type. In the one produced by de Fontaine & Co. in Hanover, the gas producer itself (Fig. 7) consists of a round shaft made of fire proof brick and jacketed with wrought-iron sheets. On top it has a charging device operated either mechanically or by hand; at the bottom, a grate, centrally rotatable, consisting of a cast-iron ash seal with the grate structure in the middle. The ash seal is filled with water in the usual manner so as to seal the inner part of the shaft away from the atmosphere. It has a worm thread on its inner surface placed spirally in stages, ending in blade-shaped surfaces, backwards, in the direction of rotation.

The most peculiar part of the construction is the central grate structure provided with worm-gear shaped stages and jaws. On the surfaces which distinguish the jaws and form the front surface of each jaw stage are located the outlet openings for the blast. The worm-thread grate, with its stages, gradually lifts and lowers the fuel column and thereby prevents the formation of cavities and suspended slag in the zone of gasification. Further, the jaws break up the slag which might accumulate between the grate and the bottom of the shaft, which is helped also through the bearing ring of the producer jacket being also provided with worm thread opposite to those of the grate elements. The worm thread of the bearing ring and of the grate elements therefore form a sort of conveying device for the slag.

An important element for the uniform operation of a rotary grate gas producer is to hold open constantly the outlet openings for the blast. In older constructions this was done by fitting these openings with special covers, but this had the disadvantage of permitting the flow of air downwards only on account of which only a comparatively small grate area and high blast pressure could be used. Since in the present gas producer, the blast openings are located in the undercut front surfaces of the jaws, a very advantageous grate area is obtained, while the blast can be directed upwards without any danger of the outlet openings being clogged up; since the grate moves in a direction opposite to that of the blast slots, the slots are at all times kept free from ashes and slag which might be deposited over them. A further important advantage of this design is that the blast openings are distributed over the entire shaft cross-section with extreme uniformity.

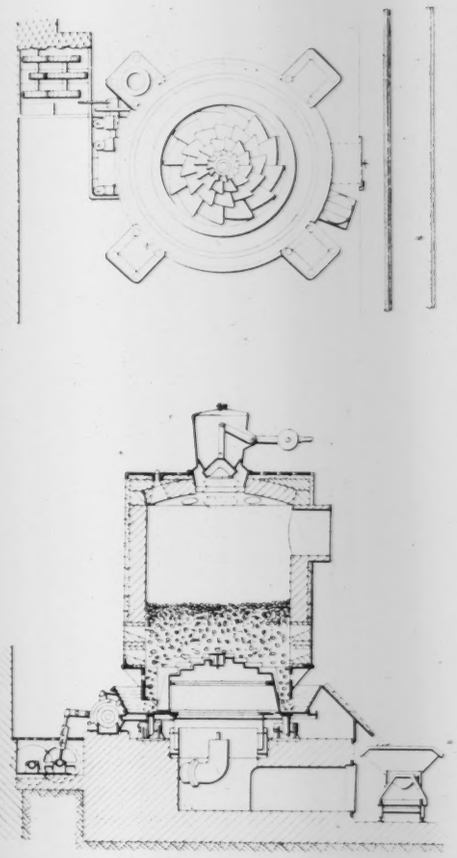


Fig. 7 De-Fontaine Revolving Grate Gas Producer

Shop Processes

Progress in the Production and Testing of Cast Iron (*Fortschritte in der Herstellung und Prüfung von Gusseisen*, Schulz. *Verhandlungen des Vereines zur Beförderung des Gewerbefleisses*, no. 1, January 1914, p. 53. 12 pp., 2 figs. *gp*). The paper discusses the above question from many points of view, such as the effort to conduct furnace operations in a more rational and scientific manner, special construction for the improvement of the quality of the castings, addition of auxiliary materials, reduction of defects in castings and creation of new testing methods for use in connection with cast iron, and standardization of specifications.

A scientific system of furnace operation may be promoted by (*a*) the establishment of definite rules for the classification of various grades of cast iron; (*b*) by constant control of auxiliary materials with respect to their quality

and weight; (*c*) by the installation of special laboratories, etc. The author points out how, within the last few years, in most of these respects, great progress has been achieved. With respect to coke, the main requirements are high heating values, which may be obtained with a minimum carbon content of 85 per cent. low oxygen content not exceeding 8 to 10 per cent and low sulphur not in excess of 0.8 per cent. The limestone must contain low silicic acid (below 3 per cent) and as low sulphur as possible (below 2 per cent) and must be in small pieces. The importance of using only the correct weights of these materials has been realized to such an extent that a German concern in Darmstadt has, for example, a special weighing arrangement with a locking device, the key of which is kept by the foreman for the purpose of making it impossible for the men to vary the proportion of additions.

To improve the quality of the castings, special cupolas have been built, such as the cupola for tempered castings, which, through a special arrangement of blast admission and construction of the tuyeres, permits of a certain superheating of the material in the cupola. By means of four powerful spindles the hearth of the cupola can be removed and gradually lowered or raised; the blast is admitted through a lower primary and an upper secondary row of tuyeres. The

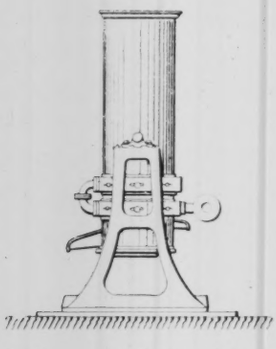


Fig. 8 Cupola for Tempered Castings

main blast is admitted into the lower main chamber and from there is introduced into the upper chamber by means of two one-eighth bends which may be cut off by dampers. The upper tuyeres are smaller than the lower ones and are arranged in staggered fashion with respect to the lower ones. The former is mainly to force the blast which was led in through the lower tuyeres more toward the inside of the shaft and produce a more extensive action of the oxygen content in the blast on the fuel. Fig. 2 shows such a type of cupola only tilted.

In order to improve the quality of cast iron used for special purposes, certain auxiliary materials have been added to it, giving sometimes quite favorable results. Many such materials may be used, but the following are the most important:

Charcoal Pig Iron. The addition of charcoal pig iron is of particular importance for the production of chilled rolls, armor plate and so on, since it gives to the casting a density and strength of structure and a very hard, smooth and nonporous surface. *Osann* published a table showing the chemical composition of such chilled castings where the very low silicon (0.5 to 0.7 per cent) and manganese (0.4 to 1 per cent) used attract particular attention. The addition of *steel shavings* tends to reduce the silicon and carbon contents and to produce thereby a fine-grained, strong texture, but such additions require a longer time and higher temperature for melting, in view of which facts they are often introduced into the cupola together with the coke charge. From the *Diller* tests of additions of steel and ferro-silicon, it appears that an addition of 12½ per cent of steel increases the strength by 25 per cent and a 25 per cent addition increased the strength of the casting 50 per cent; but a higher increase of strength with greater additions of steel could not be observed. The Borsig Co., of Tegel (near Berlin), has lately introduced the addition of iron briquettes with a large number of cavities; these briquettes are produced without any binder, and melt, therefore, much easier than ordinary steel shavings. Such briquettes, whether produced without further additions or with the use of lime water, reduce the carbon and raise the silicon waste as well as the ability of the iron to take up sulphur, but leave the manganese contents unaffected; the castings produced with the addition of briquettes show a finer grained fracture, are much less subject to hardening than the ordinary cast iron, are easily machined and appear to be very strong.

Additions of Titanium and Thermit. These additions have been made either in the form of titanium alloys such as ferro-titanium or as thermit-titanium. By the addition of ferro-titanium have been produced dense, free from porosity castings showing a higher resistance against shocks, higher strength, and better ability to be machined and polished than ordinary castings. On the other side, however, *Treuheit* has found from careful tests that titanium alloys only partly with cast iron, and that although it is a very good deoxidizer, aluminum is better suited for this purpose.

The *thermit titanium* investigated by Goldschmidt is claimed to produce a casting free from porosity and of good quality. As the thermit packed in cartridges must be immersed by means of an iron rod under the surface of the metal bath, which produces a violent boiling of the bath, this process is somewhat complicated and not entirely exempt from danger. The Titanium Company of Dresden claims, however, to have obtained by this means a material increase in the strength of casting at a cost of the addition of 0.25 per cent of titanium.

The addition of *vanadium* also has a deoxidizing effect, and, according to tests of several investigators, increases the strength of the material, at the cost, however, of elongation. Hatfield shows that vanadium prevents the separation of carbon as graphite and raises the stability of the carbides. While in America, additions of vanadium up to 0.1 per cent have proved to be of advantage for locomotive cylinders, its use in the foundries in Germany, on account of the high cost of vanadium, is only limited. *Ferro-silicon* is probably most widely used as an auxiliary material. It improves the mechanical properties of the casting and favorably affects the separation of graphite. Tests made by *Outerbridge* and *Westhoff* have shown that ferro-silicon when added in the ladles may be used to produce from the same heat various grades of castings, while recent tests by *Lissler* have shown that a large amount of ferro-silicon helps to produce castings unaffected by acids to such an extent that they may contain any kind of acid, including hydrofluoric.

The disadvantages of the addition of ferro-silicon lie in the fact that the castings, after pouring, undergo a strong contraction and are therefore brittle. The addition of *alumi-*

num does not entirely eliminate this disadvantage. Besides this, ferro-silicon when subjected to the influence of humidity is decomposed and may cause dangerous explosions or poisoning. This may be obviated by covering the ferro-silicon with paraffin and, above all, in taking care that the ladles and vessels are perfectly dry and well preheated. *Piping* may be avoided by making the risers or cropheads so large as to take up the entire liquid part of the iron in which the pipe may form. Thus, *Messerschmidt* quotes minimum values for risers used in casting steam cylinders. The formation of pipe also may be kept down by the use of iron low in phosphorus (0.1 per cent).

As regards the production of *internal stresses* in castings, the author recommends the usual care in avoiding sudden contractions of area, and in addition states that they may be minimized by reducing the manganese and sulphur, as shown by the tests of *Keep* and *West*. *Porter* shows further that the formation of blow holes is invariably increased by the use of cast iron in which there are combinations of sulphur with a varying percentage of oxygen. Therefore only iron, made of easily reduced ores and produced in a furnace at a not too rapid rate and with a sufficient amount of fuel, should be used.

As regards new methods of testing, the author calls attention to the fact that a number of investigators have lately thoroughly studied the conditions which affect the taking of samples. It has been shown, for example, that the results of carbon contents determinations are materially affected by the fact of whether the shavings taken are thick or thin. The sulphur contents determinations are affected by the sample being taken from the upper or lower part of the casting, the upper part generally being richer in sulphur. The silicon determinations depend upon whether the sample is taken from the central part of the casting or from its periphery, since, as has been shown by *Martens* on steel tests, the silicon content at the rim is much greater than that at the hub. The same is also true for phosphorus and manganese; the phosphorus content varies during pouring, which easily produces segregation. The properties of the casting are also affected by the rate of cooling and thickness of the piece, since the graphite contents are lower in pieces of small cross-sections.

As regards the methods of making rapid analyses, the system used in the Krupp laboratories deserves particular mention, since there, in 1909 and 1910, they made 1500 or more daily analyses. Special methods have been worked out to make rapid and sufficiently reliable determinations of carbon, silicon, manganese, phosphorus and sulphur. The author indicates briefly the processes used for the determination of these materials by various chemists.

INVESTIGATION OF AUTOGENOUS PROCESSES OF CUTTING METALS (*Untersuchungen über autogene Schneidverfahren*, R. Plinienger. *Zeits. für komprimierte und flüssige Gase*, vol. 16, no. 1, p. 6, January 1914. Serial article, not finished. *cA*). While the process of cutting metals by a mixture of oxygen and air or acetylene is no longer new, the details of the process have not as yet been fully established. The author, in his tests executed in the laboratory of the chemical factory of Griesheim Elektron, May to August 1912, determined to investigate the following points:

a The influences of the various percentages of oxygen on the speed of cutting and oxygen consumption

b The constitution of the chips produced with various materials and the determination of the theoretical amount of oxygen consumption

c Investigation of the influence of temperature of oxygen, the material cut and determination of temperature in the cut, by means of a Wanner pyrometer

d Investigation of the surfaces of cutting with relation to their aspects and the possibility of their application in engineering

e Investigation of the metallographic variations produced in the metal

For the tests, sheets SM-1, of uniform quality and carbon content of 0.12 per cent and of the following dimensions:

(1) d = 20 mm.—0.8 in.
(2) d = 40 mm.—1.6 in. } size 1 m. x 2 m. (3.28 ft. x 6.56 ft.)
(3) d = 60 mm.—2.4 in.

were used, and in addition, a sheet of nickel steel was investigated with a content of nickel of 22.25 per cent and 40 mm. (1.6 in.) thick. The length of cut in all cases was

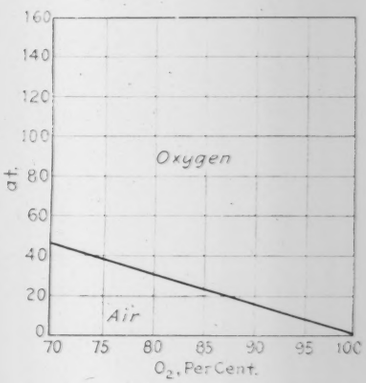


FIG. 9 DIAGRAM FOR DETERMINING THE OXYGEN CONTENT (PERCENTAGE) IN A BOTTLE CONTAINING A MIXTURE OF OXYGEN AND AIR

500 mm. (say 20 in.) and the width of the strips cut off was always 25 mm. or 1 in.

In this test oxygen was used, which was obtained from liquid air by means of rectification, while its contents was established in one of the following two ways: Generally air was pumped in the compressor house into a bottle, which was then filled up with oxygen to a pressure of 150 atmospheres, respective amounts of air and oxygen being determined approximately from the chart as shown in Fig. 1, in which the abscissae indicate the desired percentages of oxygen while on the ordinates are plotted the necessary amounts of air in atmospheres.

This method, however, gave only approximate values, and when the percentage of oxygen was desired to be known exactly, air and oxygen were allowed to flow through two different bottles (the air at a pressure of 170 atmospheres), the flow continuing until the mixture was brought up to the desired percentage. Sometimes, however, to obtain the desired contents of oxygen, as many as 30 analyses were required. These analyses were made with special testing glasses calibrated on the Bunte burette with pyrogallol as the absorption liquid. To obtain the greatest possible uniformity of the tests, the same operator was employed to make all the cuttings, thus eliminating so far as possible the influence of the personal peculiarities of the operator. He was connected with the autogenous cutting of metals almost

from the inception of this process, and it had been observed that with the same consumption of oxygen, he had obtained an approximately uniform speed of cutting. The author gives several photographs of pieces cut at various speeds. Fig. 2 shows a mixture where 98.5 per cent of oxygen was used.

If the speed of cutting is too slow the oxygen jet eats into the metal; if too great, the cut is apt to be interrupted. The various speeds of cutting can be easily recognized from the appearance of the edges of the cut, so that after a certain amount of experience one can easily determine at which speed the cut was made. With the oxygen content less than 85 per cent, it was not always possible to adhere

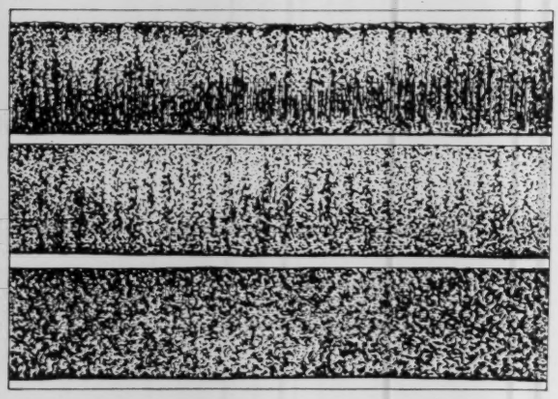


Fig. 10 Appearance of Cuts Made at Various Speeds

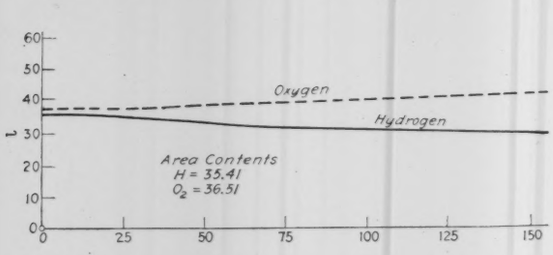


Fig. 11 Curves for Determining Quantities of Oxygen and Hydrogen (in liters) Corresponding to a Fall of Pressure of One Atmosphere at Certain Pressures.

to this rule and in order to prevent the rough edges due to the action of the oxygen jet it was necessary to cut at a comparatively high speed. Various precautions were taken to obtain reliable data for speed of cutting; thus the time of cutting was reckoned not from the edge of the plate, but always from the moment after 50 mm. (2 in.) of the cutting had been made. Further, in order to secure the same test conditions, the plate, after each cutting, was carefully cooled in water, since, as appeared later on, even a slight rise in temperature produced a remarkable difference in the speed of cutting and the consumption of oxygen. This cooling, especially in the case of thicker plate, took a great amount of time.

Determination of Gas Consumption. The consumption of oxygen was determined by the fall of pressure in the flask. Up to 20 atmospheres calculation was possible in accordance with the Boyle-Mariott law, since the weight of the contents of the flask was exactly proportional to the pressure, but at higher pressures there was a noticeable deviation from this law, as the author has determined by special tests made with oxygen and hydrogen. He found that the line of pressures for oxygen from 50 atmospheres up passed considerably below the PV-line, while for hydrogen it was considerably above it. These deviations are not constant and the hydrogen line shows a slight kink between 40 and 80 atmospheres, while the oxygen line is somewhat inflected between 60 and 100 atmospheres.

The author also made a control determination of the experimentally determined curve by analytical calculation in accordance with the Vander Waals equation

$$\left(p + \frac{a}{v^2}\right)(v - b) = 1 + \alpha t$$

for oxygen and hydrogen. He found that the curves derived from this equation coincided almost exactly with the experimental curves, the difference being such as was probably due to the inexactness of the manometers and errors in observation. By this means, it is possible to determine the gas consumption analytically from the known fall of pressure. This process, when a large number of readings is to be taken, is tedious and not very accurate; therefore another pair of curves, shown in Fig. 5, has been derived, which shows exactly how many liters of oxygen and hydrogen correspond at certain pressures to a fall of pressure of 1 atmosphere. These curves have been derived by differentiation from the curves obtained by measurement and shown in an illustration not reproduced here. They hold, however, only for flasks of the size indicated, and for flasks of different sizes require a proportional recalculation.

Steam Engineering

Utilization of Sources of Natural Steam in Tuscany (*L'utilisation pour la force motrice des sources de vapeur naturelle de la Toscane*, G. Espitallier. *Le Génie Civil*, vol. 64, no. 17, p. 331, February 21, 1914. 3 pp., 4 figs. *d*). There are in Italy a number of so-called *soffioni* (blowers) or sources of natural steam created by the volcanic activity underground. It happens that in the section of the country where these *soffioni* occur, viz., in the northern part of the Tuscany mountains, there are also a number of *lagoni*, lakes of hot water containing important percentages of boracic acid. About a hundred years ago a Frenchman, de Larderel, had the happy idea of capturing the sources of natural steam and using the heat thus obtained for the evaporation of the boracic acid solution and its concentration and treatment. From these beginnings rose the powerful "Società Boracifera di Larderello" of today, and the present article describes the modern boiler installation of the plant designed to be used in connection with a turbo-alternator aggregate. The difficulty which had to be overcome lay in the presence of sulphurous acid and solutions of boracic acid and ammonia in the natural steam, which, while causing no appreciable trouble in reciprocating engines, were considered to be highly undesirable in steam turbine operation where there is a much greater tendency towards deterioration of the metal. A special Prache and Bouillon boiler is therefore used, in which the natural steam generates a secondary steam from pure water, the pressure of the natural steam being 3.5 atmospheres, and of the secondary steam, 3 atmospheres. The article describes and illustrates the construction of this special boiler in detail.

INFLUENCE OF TEMPERATURE OF SUPERHEAT ON STEAM CONSUMPTION OF ENGINES (*Influence de la température de surchauffe sur la consommation des machines à vapeur*, V. Kammerer. *Bulletin de la Société industrielle de Mulhouse*, vol. 83, no. 10, p. 815, December 1913. 34 pp., 7 figs. *tA*). The influence of superheating on the steam consumption of engines has been investigated several times, both theoretically and experimentally; in particular by Witz, Délaporte, and Berner. But nearly all investigators have attached particular importance to the determination of the economy of superheated steam as compared with saturated. In practice, however, it often happens that an engine sold under a certain guarantee, is tested at temperatures not exactly like those stated in the guarantee conditions and in such cases it becomes necessary to use a certain correction factor so as to bring the test results in accordance with the conditions of the guarantee.

This correction factor expresses clearly the influence of the temperature of the steam on the steam consumption of the engine, all other conditions, such as admission and exhaust, pressure load, etc., being equal. In this case, the difference between superheated and saturated steam is of no interest whatever, as in most cases the engines are not designed to work with saturated steam at all. This question of the influence of temperature on steam consumption cannot at the present time be solved in any other way than by experiments, since we know that the economies obtained in practice with superheated steam differ materially from those which theoretical considerations lead one to expect. To solve this question without making special experiments, the author made a search in literature and in the files of the association for data of tests made on the same engines at different temperatures of steam, and he found such data for one single-cylinder engine, three single-cylinder straight-flow engines, eight two-cylinder engines and three three-cylinder engines, all condensing, and four engines without condensation—two single-cylinder and two two-cylinder. The article describes in detail the construction of these engines and the data of tests, from which the author drew his comparisons. Owing to lack of space, only the main conclusions arrived at in this investigation will be reported here.

The first and most important conclusion is that it is impossible to formulate a general rule which would apply to all engines or even to a certain group of engines, and would express the variation in consumption as a function of the temperature of steam. In general, the influence of temperature of steam is proportional to the consumption proper of the engine, i.e., inversely proportional to the efficiency of design. But these two magnitudes, viz., the temperature and consumption—are not as closely and definitely related as was previously believed. The author found, especially among two and three-cylinder engines, engines with approximately equal thermo-dynamic efficiencies in which superheat produced very different variations in comsumption, which is quite natural since the influence of temperature on steam consumption depends on a number of factors, the action of which may either add itself or, on the contrary, compensate for each other. Among such factors are number of cylinders, degree of expansion, dimensions of cylinders, dimensions of clearances, speed, distribution, presence of a jacket, etc.

The tests of Vinçotte indicate that in the same engine the influence of superheat on consumption varied from 9.5 to 5 grams per deg. cent. when the load went down from 300 to 100 h.p. But even if it is impossible to formulate a general rule, these tests indicate several facts of interest: for the larger number of condensing engines, consumption up to a temperature of about 300 deg. cent. (572 deg. fahr.) is strictly a linear function of the temperature, that is, it decreases in proportion to the increase of temperature. This proportion appears to continue even beyond 300 deg. cent. (572 deg. fahr.) for engines provided with a jacket of the small cylinder, while for those which are not so equipped, the advantage brought by the superheat begins to decrease when one passes the above limit of temperature down to a considerably lower value. This appears to remain constant until about 500 deg. cent. (932 deg. fahr.), the limit of temperature attainable in practice. In other words, the curves representing the consumption as a function of temperature for condensing engines provided with jackets are straight lines, while for engines without jackets, they are curves with more or less pronounced convexity directed toward the origin. Further, the beneficial influence of superheat on consumption appears to be stronger the less economical is the engine itself. Non-condensing engines, whether single or double expansion, are strongly affected by the superheat, even though the absence of a condenser would lead one to suppose that the loss by initial cooling would be less than in the condensing engine. However, here the number of tests available is not sufficient to indicate a certain average.

The original article reproduces a number of curves which were taken from the tests referred to and plotted by the author.

UNCLEAN STEAM (*Unreiner Dampf*, F. Dohne. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 6, p. 206, February 7, 1914. 5 pp., 5 figs. *ep*). The tendency to increase the output of stationary boilers led to the production of types known as high-duty boilers or inclined-tube boilers, which, in comparison with the usual kind of tubulous boilers, possess the advantage of better utilization of the available floor areas and produce far larger amounts of steam. Further, they can be started in a shorter time and more rapidly brought to a high output. But these advantages are, to a certain extent, counteracted by certain disadvantages: among others, their greater sensitiveness to troubles due to poor feedwater and their small water contents which may lead to troubles when the demand for steam is irregular.

In addition, there is present a danger that a part of the boiler water may be carried over to the superheater and piping, so that even in uniform operation, one has to count on wet steam, especially when the surface of evaporation is comparatively small. And when the load on the boiler is so large that the water circulation is affected, violent boiling in the upper drum may make it altogether impossible to obtain a regular steam supply. These critical limits of load form one of the distinctive characteristics of the various types of inclined tubular boilers.

Priming of boilers has been observed particularly often after the water became enriched with salts. A high salt content easily produces retardation of ebullition and foaming, with the result that large amounts of water are driven over into the superheater. If at the same time an overload occurs with varying demand for steam, and perhaps along with an oversupply of feedwater to the boiler, it may happen

that the amounts of water carried over into the superheater may be so large that the superheater may be unable to vaporize it, with resultant production of water hammer and possible destruction of machinery. Further, such violent ebullition of the water in the boiler easily opens the safety valves, which in itself involves a serious source of danger to the boiler attendants. But even when the water is carried over into the superheater in a less violent manner, one cannot rely upon the superheater as an auxiliary evaporator. It is not designed for evaporating water even under the most favorable conditions; that is, when it escapes from the upper drum and in mixture with steam. Here, however, the amounts of water are much larger, and could be evaporated in the superheater without injurious effects only if the feedwater is technically pure, i.e., when the additional water has been properly distilled in the evaporators. If, however, the feedwater is impure and is more or less mixed with undistilled water, even when chemical cleaning has been used, the water carried over from the boiler forms deposits in the superheaters which, in accordance with the nature of the feedwater, may consist of scale or deposits of salts (common salt or sodium sulphate). These deposits attach themselves to the tube walls and very seriously affect the heat transmission and, as a result, the strength of the metal in the pipes.

Experiments have shown that steam may carry particles of such deposits down into the machinery, unless they are previously caught, and in the machinery such foreign bodies produce injurious effects in many ways. For example, they cause a material wear on the nozzles and blades of steam turbines, while in the regulating elements and in the body of the turbine itself deposits are formed which finally greatly lower the output of the aggregate, apart from the injuries which may be caused by larger pieces carried into the turbine. In reciprocating engines these impurities produce extreme wear of the piston, piston rings and cylinder surfaces, and may also produce saponification of the lubricating oil and wear of the sliding parts. The following example cited by the author from practical experience may explain the above statement:

Several months after the installation of the plant shown in Fig. A, several superheater tubes connected with the boiler burst. The investigation showed that nearly all the superheater tubes have been annealed. The boiler had a heating area of approximately 416 qm. (4476 sq. ft.) and the superheater about 144 qm. (1550 sq. ft). Over the water chamber is an upper drum of about 1800 mm. (say 70 in.) in diameter and 7050 mm. (say 277 in.) jacket length. The headers of 216 tubes each of a diameter of 108/100.5 mm. (4.2/4 in.) and 5500 mm. (220 in.) long were inclined to each other at an angle of 15 deg. The feed-water was admitted into the upper drum having been previously passed through an evaporating apparatus. The steam was taken from the front part of the boiler through an outflow pipe into which was built a water separator tank. The boiler was designed for a normal load of 20 kg. per 1 qm. (4.1 lb. per sq. ft.) and for a maximum continuous output of 25 kg., while for a short time up to 30 kg. (6.17 lb. per sq. ft.) could be evaporated.

Steam was produced at 15 atmospheres pressure and superheat of 360 to 400 deg. cent. (680 to 752 deg. fahr.). The water space of the boiler is about 22.5 cbm.; the steam space about 9.2 cbm., and the surface of evaporation about

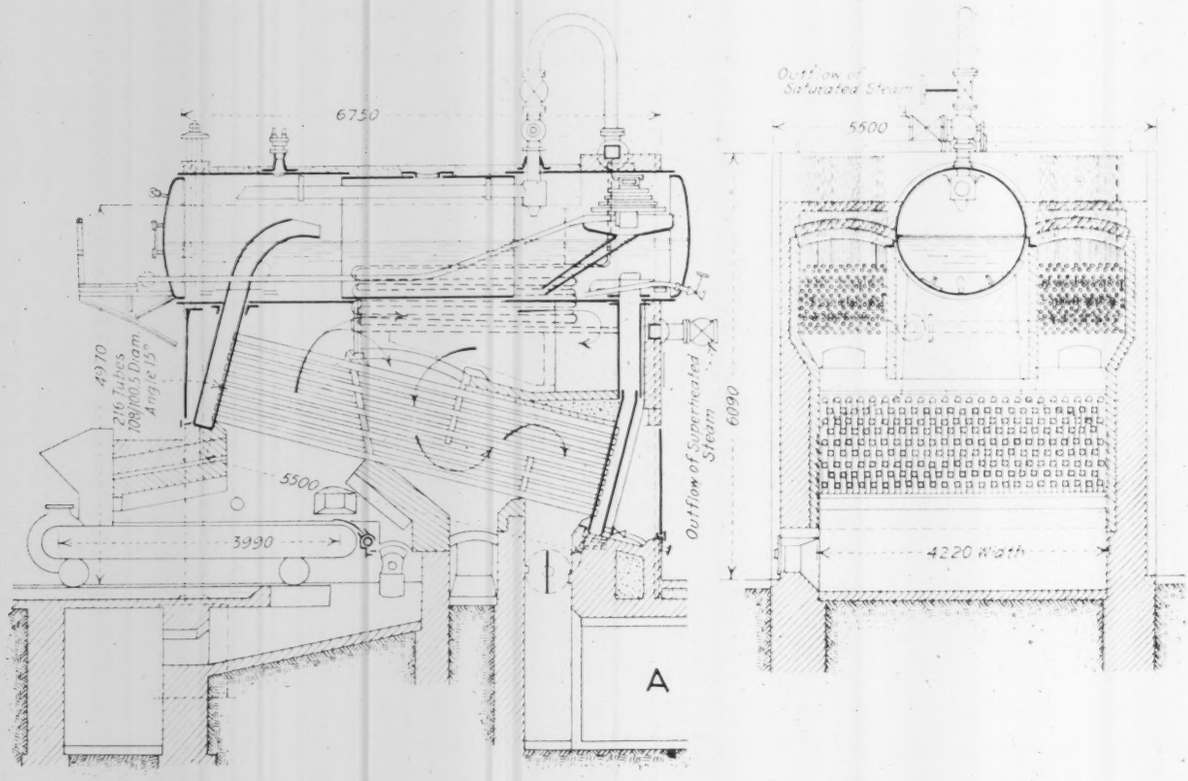


Fig. 12A Boiler Plant where Trouble was Experienced on Account of Unclean Steam: Initial Installation

13 qm. The load on the latter, with the demand from the boiler of 25 kg., is therefore approximately 800 kg. qm. (16.4 lb. per sq. ft.). The superheated tubes of 44.5/37 mm. in diameter are built in on both sides of the upper drum. For the admission of steam to and outflow from the superheater, collector chambers are provided located transversely over the entire width of the boiler. Each of the boilers is provided with a double chain grate on which coal dust up to 10 mm. (0.4 in.) grain and approximately 6000 WE (10,800 B.t.u. per lb.) heating volume is burned. A common flue gas preheater of about 720 qm. (7749 sq. ft.) is provided for all of the three boilers into which the feedwater, after it has been purified by the lime-soda process, enters with a temperature of about 90 deg. cent. (194 deg. fahr.).

During the investigation, the conditions of operation were unfavorable, as there were rapid and large variations in the amount of steam taken. This was not sufficiently well-known when the boilers were designed, so that special measures had not been taken to avoid the production of wet steam. A thorough investigation of the plant has shown that the largest part of the superheater tubes were coated on the inside with a hard crust, which was in the neighborhood of the entrance to the collector chamber approximately 2 mm. (0.08 in.) thick. Farther on, away from the upper drum, there was a heavy deposit of a gray color, practically filling up some of the pipes, and deposits were found all the way down to the water separator of the steam turbine; but while in the superheater proper they were hard and had the appearance of boiler scale; at the outlet from the superheater and in the live steam piping they were of less solid consistency. A noticeable difference was also observable in that the deposits in the superheater had no distinct taste, while in the collector chamber and adjoining pipes they had a salty taste. In order to explain the presence and nature of these deposits, careful analyses were made of the feedwater, and various kinds of deposits (the original article gives the analyses in detail); it was found that the deposits consisted mainly of sodium chloride, sodium sulphate, calcium chloride and manganese carbonate, or mainly of materials which could not have been evaporated together with the steam since none of them become volatile at the pressures and temperatures there available. All these deposits could have been carried over only with the water which has been taken up from the boiler into the superheater and piping by the steam.

It was of some interest to find out why the deposits in the two parts of the plant (the superheater and live steam piping) should have been of such a different nature, and the explanation appears to be as follows: When mechanically impure concentrated boiler feedwater was carried over with the steam, deposits were formed in which must have been present the elements of boiler scale formation (with a preeminence of calcium carbonate) and salts (common salt and sodium sulphate). Masses of this composition would first deposit in the superheater, while lighter and more soluble constituents of the scale would be subsequently washed-out by boiling steam, which would carry them over into the live steam piping and deposit there. To remedy these conditions, in front of the superheater a special container, Fig. *B*, *C* and *D* has been installed, about 800 mm. (32 in.) in diameter and 5000 mm. (200 in.) long, in which the steam has a chance to free itself of the water and impurities. In addition, in the piping immediately in front of this auxiliary container, a water separator has been installed. The steam enters the container in the middle and leaves it from both ends.

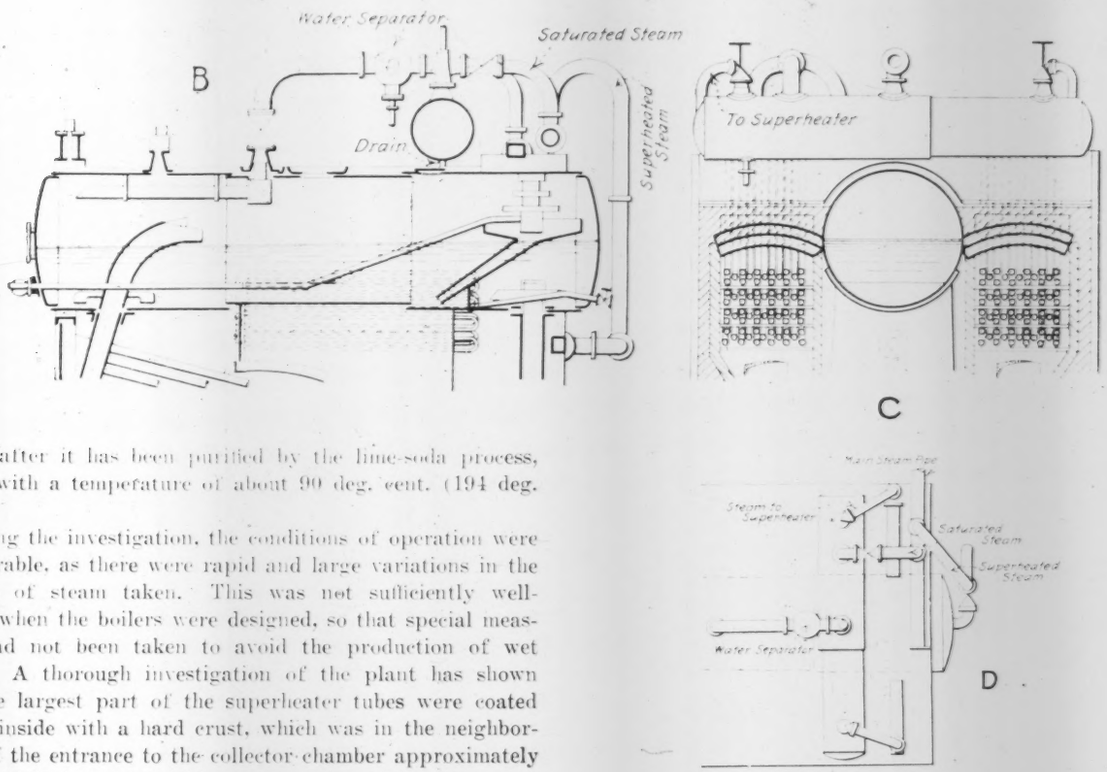


Fig. 12B, C, D Same Plant as in Fig. 12A: Improved Installation

In order to secure a uniform flow of steam through both halves of the superheater, the collector chamber has been divided as shown in Fig. C and D, in addition to which care has been exercised to daily blow off the boiler, letting the water off at frequent intervals to keep the salt content in the feedwater as low as possible, while at the same time, the steam demand system has been so modified as to prevent at least the most violent variations. Since then, the boilers have worked without trouble, with an average output of 25 kg. per 1 qm. (5.1 lb. per sq. ft.), and no trouble with the

bursting of superheated pipes has been experienced, although the feedwater remains the same as before and has been handled in the same manner as previously.

The article describes also a second case of a similar nature, where a reciprocating engine has been used.

As regards oil deposits in the reciprocating engine, attention may be called to the fact that often there is in them a considerable amount of iron oxide which may be explained by attacks on the iron of the boiler, superheaters or pipes. This is especially noticeable at high superheats, and may be intensified by the presence of caustic soda, which may be produced in the boiler from an excess of common soda. The iron oxide in combination with the deposits from the boiler water and lubricating oil forms practically insoluble deposits, which may often lead to ruptures in the machine's parts.

Strength of Materials and Materials of Construction

Arsenic in Rails (*Myshyak v relsakh*, A. I. Mitinski. *Journal of the Russian Metallurgical Society* (in Russian), no. 5, 1913, p. 650, 9 pp., *e*). The question of the presence of arsenic in rolled steel becomes of importance only occasionally, when it is initially present in pig iron (i. e. in the ore) since it is never intentionally introduced into the metal.

The Kerch ore, mined in the south of Russia, contains from 0.08 to 0.10 per cent arsenic; since the arsenic is oxydized somewhat more slowly than the iron itself, its percentage is practically unaffected by the metallurgical operations which the ore undergoes, though the absolute amount of arsenic present in the steel is somewhat reduced in the basic process. The author, together with Prof. A. A. Baykoff, made a thorough investigation of the influence of arsenic on rolled steel. The contents of arsenic have been intentionally increased by introducing metallic arsenic in boxes made of thin sheet iron into the ingot molds. The carbon contents were 0.35, 0.40 and 0.45 per cent, while the arsenic varied from 0.2 to 0.3 to 0.4 per cent. The temperatures were observed by the Wanner pyrometer; the strength of the test pieces measured by the impact test. The article gives full data of the tests, the present abstract containing only the main results.

It has been found that rails containing carbon in the neighborhood of 0.5 per cent exhibited great brittleness; this may have been due to the unusual high percentage of manganese which was as high as 1.09 to 1.17 per cent; rails with approximately 0.4 per cent carbon showed an evident increase of brittleness when the arsenic contents pass 0.25 per cent.

As regards simultaneous presence of phosphorus, it has been found that rails which contain the least amount of it prove to be the best of the group; this completely confirms the view that in order to eliminate brittleness in metal containing arsenic, the metal must be of low carbon and low phosphorus. From the tests made it does not appear that the presence of arsenic produces any apparent effect on the mechanical properties of the metal in so far as they are characterized by tensile tests. As regards macrostructure the introduction of arsenic causes a noticeable thickening of the ferrite lines. Further tests have shown that the increase of the arsenic content intensifies also the danger of rail breakages in very cold weather. They have likewise shown that manganese in large quantities is good only in very low-carbon steel. On the whole, the tests have shown that arsenic in quantities up to 0.25, or even 0.3 per cent in rail steel cannot be considered as absolutely inadmissible, but the steel must be dephosphorized as much as possible, and should contain as little carbon as possible, a low manganese content also being advisable under such conditions, although generally a comparatively high manganese content might do no harm.

As regards rolling, the arsenic rails have not exhibited any peculiarities.

Museums of Social Engineering in Germany and Abroad (*Die Sozialtechnischen Museen im In- und Auslande*, K. Hartmann. *Verhandlungen des Vereines zur Beförderung des Gewerbefleisses*, no. 1, January 1914, p. 65. Serial article, not finished, *d*). The article describes briefly the importance of museums, with relation to what the Germans calls "Social Engineering," both in Germany and abroad. A somewhat fuller description is given of the museums in Charlottenbourg and Munich.

ENGINEERING SOCIETIES

AMERICAN CHEMICAL SOCIETY

Journal, vol. 34, no. 3, March 1914, Easton, Pa.

The Compressibility of Ice, Theodore W. Richards and Clarence L. Speyers (4 pp., 1 fig. *e*). The investigation was conducted during the year 1909 and a preliminary report giving the results but no details was published in the year book of the Carnegie Institute of Washington for 1910. The present publication gives complete detail of the methods used, a summary of the investigation being presented by Mr. Richards (C. L. Speyers is dead), as follows:

The compressibility of ice between 100 and 500 megabars is found to be 0.0000120 at —7.03 deg. cent., or about one-quarter of the compressibility of water at neighboring temperatures. It is found not to decrease remarkably as the pressure increases. This is probably the first direct determination of the compressibility of common ice which has ever been made. The difference between the low result and the higher value obtained by Bridgman through indirect calculation is probably due, at least in part, to the existence of a large temperature coefficient.

AMERICAN PEAT SOCIETY

Journal, Vol. 6, no. 4, October 1913, Toledo, Ohio

Practical Peat Utilization, John N. Hoff

Peat Powder as Fuel for Locomotives (Abstracted)

Peat Powder as Fuel for Locomotives (1 p. *d*). It has recently been announced that von Porat, a Swedish engineer, has perfected a process for utilizing peat powder as fuel for locomotives. The powder is manufactured by the Ekelund process which, in itself, does not appear to have made much headway as yet. In the von Porat system the peat powder is fed by an automatic process into the furnace of the locomotive, and it is claimed that substantially the same results can be obtained from 1½ tons of peat powder as from 1 ton of coal. The powder may be burned with admixture of about 5 per cent of coal. No change has been made in the boiler or fire-box except the installation of special apparatus, the powder passing from the tender to the fire-box through a conveyor pipe. No cold air is allowed to enter the fire-box.

AMERICAN SOCIETY OF CIVIL ENGINEERS

Proceedings, vol. 40, no. 2, February 1914, New York

An Investigation of Sand-Clay Mixtures for Road Surfacing, John C. Koch

Report on a Series of Tests on Concrete Columns Reinforced with a Spiral of Steel, C. G. Wrentmore, Hugh Brodie, and C. O. Carey (Abstracted)

REPORT ON A SERIES OF TESTS ON CONCRETE COLUMNS REINFORCED WITH A SPIRAL OF STEEL, C. G. Wrentmore, Hugh Brodie and C. O. Carey. (Paper read March 18, 1914, 43 pp., 18 figs. *et.1*). The tests described in this report were made in an effort to design columns of reinforced concrete even though low stresses and excessive quantity of material might be required to insure safety. Experiments on the ultimate strength of columns with longitudinal steel bars imbedded in the concrete indicate that such reinforcement, unless hooped or banded at frequent intervals, could not be relied upon to increase the strength of the column, and in some cases might even render its strength less. The present tests were planned to determine the longitudinal and lateral deformations of the columns under various loads, increasing from zero to something above the probable maximum working strength with varying quantities of reinforcement and at different ages; also the ultimate strength and the load at the first visible sign of failure. From the deformation was to be determined the change in unit length for the various loads, the modulus of elasticity and Poisson's ratio with an idea that comparison of the results should show the influence of the reinforcements on these several quantities.

The spirals of steel were put on in two ways. In some cases they were wound on the concrete shaft after casting by placing the column in a lathe and winding the wire on under constant tension sufficient to bed it slightly in the concrete. This was done just before testing at the age of 28 days, the end of the wire being anchored securely in the column very near the winding end, the tension then applied and a dozen turns wound on as close as they would lie in order to insure against failure at the end; the spiral was then spaced by using the lathe screw until within 1 inch of the other end; then another dozen turns were run on close together. In the remaining columns the spirals were made up and set in place in the form and the concrete was then poured. The longitudinal bars of the reinforcement were barely sufficient to hold the spiral in place. There were strips of No. 24 gage galvanized iron 7/16-in. wide and notches 7/32-in. deep, accurately spaced by machine. The consecutive turns of the spiral were dropped into these notches and fastened by pinching down the lugs formed in cutting the notches. Four such spacing strips were used for each coil, and as they were so light, considerable care was necessary to insure the proper location of the reinforcement.

The article gives in considerable detail the methods of test determination of extensometer constancy; computation of values and test data cannot all be tabulated owing to a lack of space. The conclusion to which the writers come are as follows: (1) The value of Poisson's ratio is approximately 8 for short-time and 7 for long-time tests. (2) The value of e is in general below 10, only exceeding that value for short time and high stress. (3) Spiral reinforcement does not, by its restraining effect on the core, perceptibly affect the values of m or e for stresses below 900 lb. per sq. in. (4) Spiral reinforcement does not perceptibly assist the concrete in carrying the load within the limits of ordinary working stresses. (5) The limit at which the first visible sign of failure occurs is raised by spiral reinforcement; this effect is greatest in short-time tests, and is perceptible for all percentages of reinforcement. (6) The plain column fails abruptly, giving no warning of approaching collapse; the hooped column may be depended on to give warning of approaching failure at from 70 to 90 per cent of the ultimate strength, when not less than 0.50 per cent of steel is used. (7) The deformation is quite irregular up to about 400 lb. per sq. in.; above this it is quite regular up to a limit which is not defined by these tests, but is well above allowable working stresses.

The tests indicate, but cannot be said to prove conclusively, that:

(8) The ultimate strength of the column is increased by spiral reinforcement by an amount roughly proportional to the quantity of steel used, up to the limit of 1.58 per cent; and above this limit the ultimate strength is simply the amount which can be carried by the granular core supported by the spiral, but with no cohesion of its own.

ASSOCIATION OF ENGINEERING SOCIETIES

Journal, vol. 52, no. 2, February 1914, St. Louis, Mo.

The Status and Duty of the Engineer, J. A. Ockerson

Recent Economies in the Sugar Industry, A. L. Webre (Abstracted)

Railroading Sixty Years Ago, C. D. Purdon

RECENT ECONOMIES IN THE SUGAR INDUSTRY, Alfred L. Webre (17 pp., 11 figs. *dh*). New conditions brought about in the sugar industry by reason of the recent tariff changes make it imperative to produce sugar more cheaply than was previously done. One of the possible economies lies in a better system of steam utilization. In a sugar factory steam is used for various purposes: it supplies energy for the operation of machinery; it is used to heat the juices from about 60 deg. to 212 deg. fahr.; in the multiple effects and in the vacuum pans. The amount of energy taken up for power purposes is small as compared with the total energy consumed, and the introduction of more economical engines, such as compound condensing instead of simple, Diesel engines or electric generators driven by steam turbines, would not bring about as great economy as might be expected, and in some directions the more economical engine might even involve heat losses. Thus the steam used in a compound condensing engine is not available for evaporation purposes, and would give up only a part of its mechanical energy, while the remainder would be absorbed in the condenser.

Under the conditions existing at present in American sugar factories where furnaces burning bagasse may be considered to give good results, the problem with which the sugar steam engineer is confronted is not power economy but heat economy, and to get over-all results he must consider not the power plant but the heating and evaporating apparatus. The present Louisiana practice in this regard is not up to the standards of Europe and other countries. There is only one Louisiana house having vapor heaters in successful operation; only two houses equipped with quadruple effects, though there are a great many triples. The majority have plain doubles and quite a number have no effects at all, using open evaporation throughout. All these will probably have to be changed to meet the present modified conditions. In Europe there has been a general devel-

opment, which the author describes in detail, to approach the complete utilization of the heat developed. He shows the gradual evolution of multiple effects. It was found in Europe that when a quadruple was operated in the manner described, there was not sufficient exhaust to do the work, but it paid better to put live steam in the first body than in the pans and heaters, as each pound of steam used in this way did several times as much work as by the old methods. A further experiment was, instead of putting live steam at 100 lb. pressure in the first steam belt, to put it into the Pauly pre-evaporator and boil the juices before permitting the steam to reach the effect under 8 lb. pressure, which involved great advantages. In fact it was found that such an apparatus did 25 to 30 per cent more work than a plain quadruple with the same steam. In addition, the vacuum in the last effect was not allowed to exceed 24 in., thus requiring less condensing water and fewer pumps. However, inasmuch as the third and fourth body operating on vapors from the preceding units after these have been robbed for the heater and the pans could do only very little work, it appeared logical to eliminate the condenser altogether, and to operate the last body atmospheric. This has been successfully accomplished under limited conditions in the Kestner effect, where it was made possible because of the high efficiency of its heating surfaces as compared with the ordinary apparatus.

The author explains in detail why it was so difficult to attain this end and what objections may be raised to the arrangement. He further shows that with this equipment, it is possible to operate a 1000-ton Louisiana house on approximately 1000 h.p., as compared with 1825 h.p. required when the ordinary double effect is used, 1480 h.p. with the triple effect and 1300 h.p. with the quadruple effect. The author believes therefore that the house equipped with an atmospheric double, a vapor heater and vapor pan will operate on bagasse alone continuously and have fuel to spare. He describes and illustrates the apparatus recommended, and gives data of tests in the form of both tables and curves.

CANADIAN SOCIETY OF CIVIL ENGINEERS

Advance proof

BRIDGE SUBSTRUCTURES BUILT BY THE PNEUMATIC METHOD, John W. Doty. The purpose of the paper is to give a few examples of sub-structure work, constructed by pneumatic methods in Canada during the last few years, and the reason for the adoption of this method in each case. It briefly describes the use of this method on the following bridge substructures: Two bridges over the Red River at Winnipeg, bridge over the St. Lawrence River near Lachine, over the Harrison River at Harrison Mills, B. C., over the St. Lawrence River near Quebec, and over Mud Lake, near Perth, Ontario. The conclusion to which the author comes is that, under certain conditions, the pneumatic method, although the most expensive one in the general classification of foundations, is also, for the given conditions, the most economical and gives a certainty of securing a suitable footing beyond any doubt, as well as insuring the speed of completion and the positive manner in which difficulties can be overcome.

CENTRAL RAILWAY CLUB

Official Proceedings, vol. 22, no. 1, January 1914, New York

AIR BRAKES: WHY THEIR POSSIBLE UTILITY AND PERFORMANCE IS NOT OBTAINED IN A HIGHER DEGREE IN ACTUAL SERVICE, Walter V. Turner (52 pp. *gpl*). Only a few points of this interesting paper can be reported here. The author, chief engineer of the Westinghouse Air Brake Company, calls attention to the fact that while a design of an air brake is a mechanical proposition, its possible utility and performances in actual service might also to a very large extent be called a problem in psychology, the human equation being an important element in the proper performance of a brake. Further, the brake may be properly divided into two parts, viz., the air operated device and the foundation brake gear, the latter comprising all of the parts affected by the operation of the brake piston, i.e., the rods, levers, shoes and truck. These, and not the air operated mechanism itself, are the variables, for it is upon these that comes the consequent wear and tear. While it may be assuming too much to expect that the car be built around the brake installation, as a matter of fact if proper economy, efficiency and safety are to be insured, this is as it should be. The truck and cars should be designed in such a manner as to include all the provisions necessary for a proper brake and its installation.

There are four factors which contribute to the result of the operation of the brake, viz., the time, the braking ratio of the design, the overall efficiency of the foundation brake gear, and the speed. (It is unreasonable, as the author shows in detail, to expect a desired stop from an arbitrarily fixed percentage of brake ratio.) The manufacturer of air actuated devices controls only one of this four, viz., the time element, and this in itself cannot be made to compensate for shortcomings in the others. The author shows by curves how the operation is affected by deviations in cylinder pressure, which in turn determines the retardation of the car, and as a consequence its relation in this respect to other cars in the train. He discusses in detail the factors affecting brake design, conditions affecting brake operation and gives some advance information on the *electro-pneumatic brake*. As regards the factors affecting brake design, he indicates eight functional relations between various magnitudes of the car, and shows that any one of these eight values can be included among what he has previously called the fundamental requirements; and further, and even more important, any one of them can be arbitrarily chosen.

The author comes, therefore, to the conclusion that the practical brake must be a harmonious, consistent whole, embracing both the brake apparatus and the entire car design.

ENGINEERS' CLUB OF PHILADELPHIA

Proceedings, vol. 31, no. 8, January 1914, Philadelphia

The Limitations of Mathematical Theory Applied to Engineering, W. G. Button (abstracted)
Colossal Waste Due to Bad Municipal Engineering, Bernard J. Newman
The Hudson River Crossing of the Catskill Aqueduct, Ralph N. Wheeler
Concrete Roadways, Lewis R. Ferguson

THE LIMITATIONS OF MATHEMATICAL THEORY AS APPLIED TO ENGINEERING, W. G. Button (16 pp., 5 figs. *tg*). The author proposes to point out some of the necessary limitations of mathematics as applied to engineering construction. The author discusses from this point of view the question of stresses in columns, framed structures, domes, arches, retaining walls, and steel base slabs. The section on steel follows herewith:

Steel to the layman is a hard, dense material of prac-

tically unlimited strength. To the man of science it is first a crystalline aggregate, crystals of perlite, martensite, hardenite, etc., held together by cementite, or a mixture of cementite with uncombined graphite. These crystals, which are beautifully shown by polishing and etching, vary in size and shape, and furthermore are very susceptible to thermic changes, affecting materially the strength of steel. They are held together by their own innate cohesive force, of which very little is known; and fracture may occur by sliding on their cleavage planes, thus splitting into smaller crystals. These lines of displacement can often be clearly seen on the etched surface, or the failure may occur in the cementing material, the crystals separating, and this is perhaps the more unusual procedure.

Going a step further into the constitution of steel, it is found that the crystals are composed of more or less complex molecules, which in turn are but solar systems of atoms, almost infinitesimal spheres separated from each other by relatively large distances, and moving at incomprehensible velocities. The division of matter is now carried still further and we must imagine the atom as made up very much smaller corpuscles, and these are possibly only vortex rings in the ether, like smoke rings in the air, which mathematically are said to be the equivalent of a solid. We will stop, however, with the molecule as being the physical unit. These molecules are interpenetrated by an imponderable substance of such apparently contradictory qualities as to be practically inconceivable of almost infinite elasticity, of a density far greater than steel, but at the same time so tenuous that they offer scarcely appreciable resistance to the motions of the heavenly bodies. Matter, however, is only a sieve with very wide meshes.

Matter is made up of atoms separated by relatively large distances, while the generally accepted idea of the other is that it is a continuum. This will enable us to get the idea of its density. Steel is porous; the density that we measure is only that of particles diffused through this ether. If we knew the density of an atom of any element we could by means of the combining numbers calculate that of an atom or molecule of steel. *The ether is the only really rigid body in the universe.* Fundamentally all molar stresses in matter resolve themselves into molecular stresses, and these are probably stresses or strains in the universal liminiferous ether. The simplest reaction of a beam on a column is to be explained rationally only by the intermolecular forces.

INSTITUTE OF MARINE ENGINEERS

Transactions, vol. 25, February 1914, Stratford

The Upkeep and Management of Boilers on a Tramp Steamer, G. A. O'Neill (Abstracted)

Report on the Circumstances attending an Explosion at an Electricity Generating Plant

THE UPKEEP AND MANAGEMENT OF BOILERS ON A TRAMP STEAMER, G. A. O'Neill (22 pp. *p*). A discussion of practical methods of the upkeep and management of boilers on a tramp steamer, and among other things, attention is called to external corrosion of boilers. On the bottoms of combustion chambers on the fire side an incrustation of scale and dirt will form, if not carefully watched, and with the combustion chamber frequently swept and scraped out, this scale obtains quite a smooth surface and appears like the plate itself. However, it can easily be detected by tapping with the round end of a hand hammer, when it will break off in flakes. If the scale is allowed to form, corrosion invariably goes on underneath it and the thickness of the plate is sometimes seriously reduced before it is noticed. Salt from leaky tubes and joints, when mixed with wet ashes, causes corrosion, and as this often occurs in the combustion chamber, it is essential to stop the least noticeable leakages as soon as possible. The boiler front end plates at the bottom suffer a great deal from contact with wet ashes.

In the discussion which followed, Jas. S. Gander stated that, so far as he had observed, this furnace corrosion did not occur when the boilers were fitted for burning oil fuel, since the whole circle of the furnace was generally used for heating surface. External corrosion from the fire side is also absent with oil fuel, as the heating surface could be kept much cleaner. He claimed important advantages from the careful use of calcinated soda: on one occasion he had been obliged to run a donkey boiler for a week on sea water, not even having the benefit of the condensed feedwater which was put into the main boilers. Soda was constantly used and attention paid to the scumming and drawing off of sediment. Upon opening up, the heavier scale found was less than 1/16 in. thick on the crown of the furnace, the other parts being practically clean. On the same vessel, with the same precautions used, the main boilers ran from February to the end of September, water being unchanged, and on opening up practically no scale was found.

James Shanks spoke about the extreme care which should be observed when circulating the water with steam pressure on the boiler. A number of engineers had been attempting to get some automatic system of circulation both for raising steam and under banked fires, but there did not appear to be any which was quite efficient. Some do excellent work while lying under banked fires, which was important in tramp steamers and should be fitted into every ship, as any engineer would hesitate in using a donkey or feed pump for circulation with a pressure of 220 lb. on the boiler. There was always danger, and some automatic system of circulating water under banked fires was needed.

INSTITUTION OF ELECTRICAL ENGINEERS

Journal, vol. 52, no. 227, February 2, 1914, London

ELECTRIC TRAIN LIGHTING SYSTEMS, T. Ferguson (13 pp., 15 figs. *cd*). The author gives a general description of the British and some continental makes of electric train lighting equipment. In conclusion he gives a table reproduced here as Table 3, Page 095.

INSTITUTION OF MECHANICAL ENGINEERS

Advance copies of dates indicated, London

Some Modern Methods of Welding, Thomas T. Heaton (abstracted)

Water as A Mechanical Agent, Edward B. Ellington (abstracted)

SOME MODERN METHODS OF WELDING, Thomas T. Heaton. (advance publication *C*, paper read February 20, 1914. 15 pp., 18 figs. *cd*). Broadly, the modern methods of welding may be divided into electric welding and gas welding. In electric welding, the chief systems are as follows:

The electric arc system, in which the best known representatives appear to be the Benardos system and the Zerener process: The Benardos system uses a direct current of about 90 volts and an amperage depending upon the thickness to be welded; in ordinary products running from 200 to 500

amperes. The work itself forms the positive pole of the arc and a carbon rod the negative pole, this arrangement being used so as to secure the greatest amount of heat in welding, as the positive pole is the hotter. The arcs are arranged in parallel, and provided with a regulator to adjust the current to the work done. In the Zerener process, there are two carbons in the same holder and a magnet which deflects the arc produced between these two carbons, downward onto the work. No current passes through the work at all.

The Strohmenger-Slaughter system may be used with either direct or alternating current. The parts to be welded are placed in juxtaposition; an electrode is laid upon and along the welding line; contact is then made between the work and one end of the electrode, which fuses by a series of arcs along the welding line, melting the electrode and coating the weld with a vitreous flux. It is claimed that this flux prevents oxidation.

Electric contact welding is done by machinery. In the Thompson-Houston process, which is a good representative of that class, the pieces to be welded are fixed in the machine, one immovable and the other in a slide rest. The piece in the movable slide is pressed by means of a screw against the other and a very heavy alternating current is passed through. The electric resistance of the joint causes a rise of temperature to welding heat and the movable piece is pressed forward until the complete union is made. The voltage is very low (from 2 to 4 volts). The current is about 16000 to 20000 amperes per sq. in.

Another method of contact welding differentiates between spot welding and roller welding. In the first, the work is upon a fixed copper contact piece and a second movable electrode is pressed upon it immediately above the fixed electrode. The current, in passing from one electrode to the other, heats and welds the work. In roller welding, electrodes are rolls which grip the work overlapped between them, heating and welding it as it travels. This system requires a good quality of metal, homogeneous and free from scale or dirt, and necessitates a somewhat delicate adjustment of the time and current; but it can produce remarkably good results in welding.

In gas welding, the best gas to use is acetylene or benzol vapor; coal gas and hydrogen have also been successfully used in conjunction with oxygen.

The author discusses in detail the strength of welded seams.

WATER AS A MECHANICAL AGENT, Edward B. Ellington. (Thomas Hawksley Lecture, delivered December 5, 1913. Advance copy B, 17 pp. *g*). This is the first lecture in a series established by the council of the Institution of Mechanical Engineers in memory of their distinguished past-president, an engineer of unusual achievement and great influence in the development of hydraulic gas and drainage machinery in Great Britain and elsewhere. The speaker gave a brief biography of Mr. Thomas Hawksley, and indicated in general the development of hydraulic engineering in its various branches during the last hundred years.

INSTITUTION OF MINING ENGINEERS

Transactions, vol. 46, part 3, 1914, London

THE ABSORPTION OF OXYGEN BY COAL, T. F. Winmill (Pt. I., 15 pp. *epA*). The results obtained in this important investigation are presented here in abstract, the reader being referred to the original article for the detailed data and tables. So far four sets of experiments have been carried out: (*a*) on the relative rates of oxidation in the various parts of the Barnsley seam; (*b*) on the effect on the rate of oxidation of reducing the oxygen content in the intake air; (*c*) on the effect of the size of the coal-dust particles on the rate of oxidation; (*d*) on the effect of temperature on the rate of oxidation.

As regards the relative rates of oxidation of the various parts of the Barnsley seam, the rates of oxidation of the various substances occurring in the seam (hard coal, soft coal, cannel coal, jacks, shale and mother of coal) have been determined at 30 deg. cent., which temperature appeared to be somewhere near a normally cool goaf temperature for the mine from which the samples were taken. The curves plotted from the results obtained show clearly, first the very rapid oxidation which takes place during the first few hours in freshly cut coal and, secondly, the fact that this is followed by a much slower absorption which persists for a long time, the results for different parts of the seam being quite similar. The amount of oxygen absorbed is roughly proportional to the content of carbonaceous matter in each substance. The mathematical analyses of these curves show that each represents with a fair degree of accuracy the sum of two chemical reactions obeying equations

$$\text{Log}_e \frac{A_1}{X_1} = K_1 T \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

$$\text{Log}_e \frac{A_2}{X_2} = K_2 T \ldots\ldots\ldots\ldots\ldots\ldots [2]$$

where A_1, A_2, K_1 and K_2 are constants, and X_1 and X_2 are the rates of absorption of oxygen in each of the substances respectively at a time T. There are here apparently two reactions, one starting with the rate of absorption of A_1 cu. c. per 100 grams of coal per hour, which falls to half in about 6 hours, and the other at A_2 cu. c. per 100 grams per hour, which falls to half in about 100 hours. The values of A_1 and A_2 represent the rate of absorption at the beginning of the experiment and the sum of A_1 and A_2 should therefore be a little greater than the first numbers in each of the corresponding tables. As a matter of fact they are less, owing to several causes. With the above equations it is possible to calculate the amount of oxygen which the coal will absorb from the beginning of the experiment to the time when it will absorb no more, and it appears that the main influence on the actual firing of the coal is due to the second reaction.

A further point of interest which is brought out by the analysis of the air which passes through the coal is the small amount of carbon dioxide that is produced in the oxidation. From the hard coal, at 30 deg. cent., less than 20 cu. c. of carbon dioxide is formed during the absorption of 760 cu. c. of oxygen.

Combustible Gases evolved during the Oxidation of Coal. At 30 deg. cent., there seems to be no carbon monoxide produced in the presence of free oxygen and the combustible gases consist, first, of methane, and later small quantities of higher hydrocarbons. The total amount of combustible gases given off by 100 grams of each substance during oxidation varies from 37 cu. c. for hard coal to 80 cu. c. for soft coal. To obtain some idea of the effect of the partial pressure of the oxygen on the rate of absorption, the intake of pure atmospheric air was replaced by a reservoir delivering at constant pressure air containing 8.28 per cent of oxygen. The coal used for the experiment was the "hards." The

absorption rate was far greater than it would have been if it were proportional to the particular pressure of the oxygen, and shows that any proposal to stop at any rate the earlier stages of spontaneous heating by a reduction in the percentage of oxygen short of the total removal of the oxygen would appear to have no basis in fact.

Effect of Fineness of Dust. In all the experiments described so far, the dust was ground to pass through a 200-mesh sieve, but further experiments were also made with dust passing through a 10-mesh and left on a 30-mesh sieve, and with dust passing through a 30-mesh and left on a 60-mesh sieve. It was found that the rate of oxidation is not simply inversely proportional to the size of the particles, which may be due to the fact that the coal is porous and the oxygen is therefore able to penetrate into the interior of each particle.

Effect of Temperature on Rate of Oxidation. After some oxygen has been absorbed, the temperature of the coal will rise and a new rate of absorption will commence. To understand how the coal goes on heating until it ultimately fires, the temperature coefficient of the rate must be known. The experiments on the variation of the rate of oxidation with temperature are not yet concluded, but what has been done indicates that this rate increases greatly with the increase of temperature. A second paper by the same author on the same subject is in course of preparation.

MANCHESTER GEOLOGICAL AND MINING SOCIETY

Some Experiences in Reversing the Main Air Currents in Coal Mines and the Mechanical Structures Involved, W. Clifford (2 pp., 10 figs. *dp*). The account in this paper is taken from the Iron and Coal Trades Review for February 13, 1914, as the original publication of the Society is not yet available.

The author describes various appliances for use in reversing the amount of air currents, the paper being based mainly on United States practice. He shows and illustrates the reversing doors designed by himself, which permit of the retention of the lines of Guibal's évasée chimney, and at the same time provides doors of sufficient length to close the chimney opening for reversal, and, by controlling the limits of their upward path, to do away with the risk of striking the revolving fan blades. He also described reversible exhaust and blow fans of various types and showed a method of reversing the main air current independently of the fan.

In the discussion that followed, Percy L. Wood stated that in England it was thought that there was a good deal of danger in reversing the ventilation. He suggested that in the case of a fire in the down-cast shaft, if a blow fan were suddenly converted into an exhaust fan there would be danger in a fiery mine. Assuming the goaves held gas when the fan was converted from a blower into an exhauster, and a large amount of pressure was taken from the workings, the gas would naturally be emitted in considerable volumes and would be drawn over the fire with probably disastrous results. On the other hand, if the exhaust fans were suddenly reversed, there would not be anything like the same danger because whatever gas happened to be in the goaf would probably be sent further into the goaf. As regards the necessity of évasée shape of outlet, the speaker made some experiments without such shapes; they reversed in something like 30 seconds and had nearly as much air in the reverse direction as in the proper direction.

Charles Pilkington stated that in England they do not want to reverse the air very often nor to have the reverse current as large as the ordinary current; all they wanted was to have a certain amount of reverse current down the pit. It was the law of the land to have the fans so constructed that they would reverse the current and not that they *must* reverse it.

NEW ENGLAND RAILROAD CLUB

February 10, 1914, Boston

Steel Passenger Cars, F. M. Brinkerhoff (33 pp., 8 figs. *dg*). The author believes that the use of steel cars will not reduce the number of accidents, but may mitigate the injury to passengers and cars when the accident does occur. Large sums, however, are involved not only in the first cost of the cars, but in the operating expenses as affected by the weight of the car, and relative cost of maintenance and repair of the various types of car body structure, so that a very thorough investigation of these questions, not only under normal conditions but also when subjected to the test of derailment or collision, becomes important. The question of weight is of great importance. A steel passenger car, properly maintained and repainted at suitable intervals, should be serviceable for from 30 to 40 years. Now assuming that the cost of power for hauling one pound of car weight per year averages $0.01 and in rapid transit service $0.05, it is obvious that $20 per year per ton for 30 to 40 years is a pretty heavy penalty for accepting a hasty or undeveloped design involving unnecessary weight. On the other hand, a saving in weight must not be made to the detriment of the maintenance cost. The design must therefore combine, to as great an extent as possible, the following essential features: (*a*) The safety and comfort of passengers; (*b*) low cost of operation; (*c*) low cost of maintenance; (*d*) moderate first cost.

In consideration of safety, not only should the capacity of the car body structure to resist collision and derailment shocks be regarded, but coöperation with the claim department may disclose many little details of finish, hardware, clearances, etc., which may have caused personal injury in the past and which can easily be avoided in a new car design.

Except in cars of a special type or cars constructed with blind ends wherein the end sill is also the buffing sill, all shock of collision impact will be received by the center sills through the medium of the draft gear and the buffing device. It is manifestly of the utmost importance to secure center sills against buckling in any direction, due to shock or load applied to the buffing sills, either in a longitudinal or vertical plane. It is usual to assume that a given shock is divided between the buffing device and draft gear in a definite proportion, but frequently heavy shocks are delivered against a closed knuckle, in which case the loading of the center sills as above assumed is not realized and the shock may produce buckling of the sills unless the draft gear should fail first, in which case the shock will be transferred to the buffing device. Also the entire sills forward of the truck may buckle in an upward direction. In order, therefore, to avoid excessive weight of the deep center sill construction necessary to meet the above described eccentric loading, it is advisable to support and align the center sills against deflection by means of suitable cross-bearers and body end sills attached to the side frames and center sills.

In this manner the center sills will be relieved of all deflection due to live or dead load and their full sections will be available to transmit longitudinal shock.

The author believes that the calculation for strength of center sill to resist end shock should be supplemented by investigation of its ability to support the car whenever, for example, the buffing sill of one car in collision over-rides the buffing sill of another car and the train has been derailed leaving the center sill unsupported at the center plate. As regards permissible weight, a consistently designed steel coach should weigh less than a wooden coach of the same dimensions and be materially stronger. As regards the type of framing, the author believes that it is essential that ample section be used in the center sill construction, to withstand the expected strains, but by the use of adequate cross-bearers, well connected to sills and side frames, it will be found possible to design suitable center sills of practically uniform section for their entire length and thus effect a great economy in weight as compared with fish-belly center sills frequently used in passenger car construction. The body end sill, with its cover plate connections, should be designed to transmit all vertical loads from the center sills to the side frames supporting and aligning the center sills against deflection in any direction. An unobstructed underframing is particularly desirable for the application and inspection of equipment; it is also desirable to utilize the entire side of the car as a truss or girder with the side as a top member instead of using the plate rail as the top member of the girder formed by the side below the windows.

In steel cars it is entirely practical to proportion and reinforce the inner piers so that very effective truss construction can be obtained. A carefully designed roof can add greatly to the ultimate shock resistance of a car structure, the side decks acting virtually as flanges for the tops, and the side frames will preserve its alignment and prevent the separating of the side plates and posts. The roof construction can also be made to afford a considerable element of safety on occasions when the car may be derailed on an embankment or bridge and overturned.

The author further recommends the elimination of joints, especially such as may be attacked by corrosion. He believes that a sleeping car weighing about 125,000 lb. complete could be designed. It is seldom that the failure of the underframe is the cause of injuries to passengers in cases of derailment or collision, but rather the inadequacy of the upper body; a redistribution of the strength members might therefore result in producing a structure offering a maximum protection to passengers with a somewhat reduced weight. As the center sill is usually the heaviest single part in the car, its permissible weight is of great importance and may be minimized by relieving it of all vertical load, so that its cross-bearing connections to high side frames which when designed in the form of a truss have ample strength to carry the entire load of the car and also to support and align the center sills against buckling. This system of high-truss side frame herein outlined is applicable to any type of car body construction.

The author discusses various other points of car design, such as brake equipment, comfort of passengers, lighting, etc., and describes in some detail the brake equipment supplied for the Rapid Transit subway cars. He illustrates his paper by numerous photographs referring mainly to the New York, Westchester & Boston Railway.

RAILWAY SIGNAL ASSOCIATION

Journal, vol. 19, no. 1, March 1911, Bethlehem, Pa.

Tests of Creosote Used in Treating Cross Ties
Tests of Cross Ties Treated with Creosote (Abstracted)
Specifications for Wood Pole Line Brackets
Specifications for Pole Line Washers
Specifications for Edison Storage Battery

TESTS OF CROSS TIES TREATED WITH CREOSOTE (2½ pp. *e*). Creosote from Carbondale, Ill., was used. The main problem of the test appears to have been to determine the conductance of the ties when dry, wet, or containing a large amount of common salt. It was found that dry creosoted ties in themselves do not possess very high conductivity, which is not increased to any great extent by the addition of a slight percentage of moisture, but the addition of a salt solution brought forth such a great reduction in the resistance as to brand the substance as a great detriment to successful track circuit maintenance. In this case, 2 lb. of salt per tie were applied, which at first sight appears to be an excessively large amount, but the accumulation of brine from refrigerator cars year after year may mean that the residue remaining in the tie may eventually approach the amount used in this test. The cross-grain measurement tends to prove that the resistance is less with the grain than along the year rings or radial lines.

ROYAL SOCIETY OF ARTS

Journal, vol. 62, no. 3196, February 20, 1914, London

THE PRESERVATION OF WOOD, A. J. Wallis-Tayler (29 pp., 12 pp. *dg*). The author enumerates various methods for the preservation of wood and discusses them in detail, referring chiefly to American practice and investigations made in this country by Mr. Bailey of the Harvard School of Forestry. He gives a list of the various processes of wood preservation used, with a brief statement of the nature of each of them as well as a list of preservative solutions.

The article presents an excellent compilation of material on wood preservation in a brief and clear form, but does not claim to include any facts not otherwise published. In the discussion which followed, Mr. J. B. Murray stated that he knew of a process which did not affect the appearance of the wood otherwise than slightly darkening it and yet gave very effective protection against fire. If treated and untreated pieces of wood were applied to a Bunsen burner, the untreated wood would burst into flame, but the treated piece would not; it would char, but not flame.

Mr. Wallis-Tayler stated that he believed that one proprietary substance was utilized by the British Post-Office authorities for rendering timber fire-proof; it is also odorless and a good antiseptic. His experience as an engineer to Sir Charles Tennant, on sugar estates in the West Indies proved that pieces of wood thoroughly impregnated with a saccharine solution were practically indestructible so far as rot was concerned; he had, however, no experience in the use of saccharine matter for large timbers, although he knows that negroes and coolies dip the handles of their tools with an object to strengthening them.

WESTERN SOCIETY OF ENGINEERS

Journal, vol. 19, no. 1, January 1914, Chicago

Factors Determining a Reasonable Charge for Public Utility Service, M. E. Cooley
Testing of Horizontal Low-Head Water Turbines at Elkhart, Indiana, Lucius B. Andrus (Abstracted)

The Grand Stand for the University of Chicago, Charles Hodgdon

TESTING HORIZONTAL LOWHEAD WATER TURBINES AT ELKHART, INDIANA, Lucius B. Andrus (54 pp., 18 figs. *de*). The author describes briefly the Elkhart hydro-electric plant in Elkhart County, Indiana, consisting at present of two complete water turbine units for driving two 1000 kva. 3 phase 4 wire 400 volt 60 cycle generator units and one 125 volt, 1/100 kw. direct current exciter generator with suitable oil pressure horizontal water wheel governors for controlling the speed of each of the water turbine units. The tests of the present machinery were made at Holyoke Water Power Company's plant at Holyoke, Mass. In Holyoke there are at present 158 water wheels in use, some of them running 10 hours per day and others from Sunday midnight to Saturday midnight, or 144 hours per week. Observations are taken giving the opening of the speed gate of each wheel and the head acting upon it, once a day and once during each night. These data are carefully preserved and from them are computed the amount discharged by each wheel and by each establishment during the quarter year, and what is known as "surplus power" thus shown to have been used is paid for at the end of the quarter. This system results in economy in the use of water and prevents the possibility of the use of same by some parties to a greater degree than the lawful quantity at any or all times and of a disregard of the rights of any other parties. This system, however, requires keeping track of the efficiency of the tur-

TABLE 3 COMPARATIVE DATA OF VARIOUS MAKES OF ELECTRIC TRAIN LIGHTING EQUIPMENT

Makers	Single or Double-battery System	Method of Transposing Batteries in Double System	Type-Constant Current or Constant Voltage	Pole-changing Device	Method of Regulation	Method of Adjusting Output	Type of Automatic Switchgear	Voltage Compensation in Lamp Circuit when Charging	Alteration of Compensation when Lamps are Switched	Alteration to Output when Main Lamp Switch is Operated	Overcharge Preventer (Type)
J. Stone & Co.	Double	On reversal of rotation (mechanical)	Constant current	Switch arm governor-operated	Slipping belt	Belt tension	Mechanical	Second battery	None	None	None
Leeds Forge Co.	Single	.....	Constant current	Brush rocker	Cam slides armature	Spring collar adjusting nut	Electrical	Lamps across fewer cells	Self-compensating	None	Breaks field current
Mather & Platt	Double	By hand switch	Constant current	None required	Armature reaction	Field resistance	Electrical	Second battery	None	By field resistance	Adds field resistance
Vicars, Ltd.	Single	.....	Constant current	Brush rocker	Automatic rheostat	Diverter	Electrical	Automatic rheostat	Automatic rheostat	Diverter has some effect	Switches extra shunt coil to main a to rheostat
Tudor Co...	Single [1]	.....	Constant current	Brush rocker	Counter compounding	Diverter	Electrical	Hot iron-wire resistances	Separate wire resistance	By field resistance	Adds extra field resistance
Silvertown	Double	Mechanical	Constant current	Governor-operated	Counter compounding	Diverter	Mechanical	Second battery	None	None	None
Brown-Boveri	Single	.....	Rising voltage if lamps not on	Brush rocker	Voltage regulator	Adjustment of regulator	Electrical	Fixed resistance	Regulator alters dynamo volts	Regulator alters dynamo volts	[2] Adds resistance in regulator circuit
Dalziel.....	Single	.....	Constant [3] voltage	None required	Differential exciter	Rheostat	Electrical and mechanical	Resistances	Each lamp or group of lamps on separate resistance	Battery charging independent	None required
Grob.....	Double [4]	Mechanical	Constant voltage	Mechanical	Series excitation armature bucking against regulating battery	.....	Mechanical	Lamps on dynamo; battery on booster	None required	Battery charging independent	None required
Buttner....	Single	.....	Constant current	None required	Armature reaction	Field resistance	Electrical	Hot wire resistance	Separate hot wire resistance	By field resistance	Adds extra field resistance
Newbold...	Single	.....	Constant current	Mechanical	Automatic rheostat	.....	Electrical	Resistances	Separate resistance	By extra coil on regulator	.....
Gould.....	Single	.....	Compound	Mechanical	Carbon powder regulator. Series and shunt	.....	Electrical	Separate regulator	Separate regulator	.....	Shunt coil of regulator

[1] Requires 25 per cent more cells on account of hot wire resistance losses. [2] The charge to the battery is increased when more lamps are switched on [3] Pure constant-voltage system. [4] Has one battery as regulator.

bine wheels, and, for the purpose of making the necessary experiments on the wheels of their tenants before they are set in the mills, the Holyoke Water Power Company has built a permanent testing flume, where wheels are usually tested at five or six different openings of the speed-gate with a final result that, for all practical purposes, the water wheel has been converted into a water meter and its discharge may be known under any of the conditions under which it is found in the mill, while its efficiency or value as a water meter is also known.

The Holyoke Water Power Company being fitted to make these tests at any time, winter or summer, and with many tests to make, it can afford to charge only a moderate amount for the test. Thus, while formerly the cost of a wheel test might readily amount to $2500, it can now be done in the special plant at a cost of from $100 to $150. There are, however, three factors of the Holyoke test which are practically fixed and do not apply to the conditions under which the water turbine will necessarily operate in a power installation:

a The head at Holyoke under which the wheels are tested may be considerably different from that at which the wheels will operate when permanently installed.

b The wheels are tested in a vertical position at Holyoke and may be erected in a horizontal position when permanently installed.

c The length of the draft tube and its form are fixed within limits in the Holyoke testing plant.

The author describes in detail how the present test was made, and in particular how the generator efficiency has been determined—the test weir arrangements, weir head water gagings, and the various weir discharge corrections. He also describes in some detail the method of conducting the test and taking the readings. In an appendix to the paper is given a complete log of the test for a 50 in. horizontal low-head water turbine showing that the actual efficiencies come within approximately 1.5 per cent of the guaranteed efficiencies—an unusually good showing for turbines of this size.

As regards the applicability of water turbines for commercial work, the author points out that owing to the high cost of overflow land, as it has to be acquired by the water power companies, and with the usual American low-head, it will cost about $250 per kw. by the time the development is completed. Now on this sum, one must allow at least 6 per cent interest, 3 per cent for depreciation and contingencies and 1 per cent for taxes, or a total of 10 per cent, equal to $25.00 per year per kw. fixed charges on a water power plant, with an attendance cost of about $4.00 per kw. per year, or total about $29.00 per year. Now a good modern steam plant will have approximately $15.00 manufacturing costs and $15.00 fixed charges per year, or a total of $30.00 per kw. per year. From a monetary standpoint there is therefore no appreciable advantage in a water power plant as compared with a steam plant, but sometimes as a matter of business policy it is preferable to build the water power plant first lest somebody should come in later on, build it and force you to buy him out in the end. The governor used was the one manufactured by the Lombard Co. It is not a standard governor, but was made for these conditions—a governor head operating the governor ball and admitting the oil to the piston is standard, but the piston or the other parts working on the shaft, moving back and forth have not been standardized. Referring to the cross section of the Holyoke test flume, the makers' guarantees were in this case based on the efficiencies obtained from the Holyoke testing flume. In the Holyoke test the wheel is used as a water meter instead of a water wheel, but when the Company finds out how much power a man has and how much water is going through the mill, they have the figures for the efficiency, and the man who can get the most power out of a certain amount of water is the man who sells the most wheels. As a result, different manufacturers would change wheels to satisfy their customers and send them down to the Holyoke Company to be tested, but this Holyoke test would not necessarily prove what the wheel could do when it was in position. For example, a test of a wheel was made at Holyoke where, by shifting it up so that four feet were added to the draft tube length, an increase in efficiency was secured of ½ per cent for each additional foot of draft tube. With right draft tube conditions, one can therefore obtain a higher efficiency on the wheels than can be obtained at Holyoke due to the draft tube conditions there.

THE SOCIETY OF ENGINEERS

Journal and Transactions, vol. 5, no. 1, January 1914, London

Electric Lighting of Steam Driven Trains, E. Kilburn Scott (22 pp., 14 figs. *ed*). The paper discusses the electric lighting of steam driven trains. It gives a brief historical sketch and the standard requirements for satisfactory train lighting system as well as a description of the apparatus used. As regards the switch regulator, which is a most important part of any system, the conditions with which it must comply are stated in the words of Rudyard B. Smith, from his paper before the Institution of Civil Engineers. The author describes in some detail the systems of Mather & Platt, Ferguson and Newton.

He also gives a brief discussion on the management of storage batteries and lamps, and expresses the opinion that Tubolite, the system of electric lighting used by shipbuilders, is suitable for illuminating railway coaches. In this system, which has been adopted on some cars of the Great Northern Railway Company in England, the long Tubolite lamps are held by means of porcelain holders in the position of maximum efficiency relative to a highly polished aluminum reflector. The light is directed upward to the white roof of the carriage and, by reflection, produces a clear well diffused light throughout the whole car. There is no direct glare and the amount of useful light for a given consumption of energy is greater than with the ordinary incandescent bulbs.

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

FOREIGN REVIEW AND REVIEW OF THE PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

THIS MONTH'S ARTICLES

The Schlotter blower, described in the first section, represents an attempt to design an efficient high-speed spiral blower. The next section, Internal-Combustion Engineering, contains an abstract of a very thorough investigation on heat transmission in the gas engine, in which the author shows that the coefficient of heat transmission is a function of time, and discusses the physical meaning of what he calls the *time element* in the coefficient of heat transmission. The same article contains also interesting data on the subject of heat radiated from a gas at a certain temperature. Arn. Lack investigates the problem of the application of crude oil engines for propelling motor vehicles, and, among other things, gives brake test data of a Büssing engine designed to be used on a military power truck. From the article it appears that there is not much chance of automobiles being propelled by Diesel engines. Another article gives comparative data of tests of a benzole and gasolene engine, showing that the former is on the whole more economical and efficient.

In the Machine Shop section is given an abstract of an investigation on thermal processes occurring in cutting metals, and on the best speeds of cutting. The investigation shows that the cutting pressure per unit of surface is inversely proportional to the cross-section of the shaving; that the rise of temperature, for shavings of equal cross-section, increases with the speed of cutting; while the efficiency of the lathe increases rapidly with increased cross-section of the shaving. The author discusses also, and expresses by equations, the variation of the rise of temperature with varying speeds of cutting, as well as the distribution of heat in the shaving.

The next section, Machine Design, contains the first part of the abstract on the governing of engines. In the Steam Engineering section will be found data of tests on heat transmission from steam to cooling water, especially interesting in that they supplement the paper published in *The Journal* by Mr. Orrok. The author shows that the temperature exponent in the equation of heat transmission may vary within wide limits; he has also determined the coefficient of heat transmission k, and presented it as a function of the velocity of flow of water. The same section contains an extensive discussion on the subject of safety of watertube boilers, and describes and analyzes the causes of several explosions of this type of boilers in Germany. The German regulations for running boilers of different working pressures on a common steam piping, and apparatus to be used in such cases, are stated in the next article. Several articles on refractory materials will be found in the section Strength of Materials and Materials of Construction.

A method of closing pores on hollow brasses has been described in a paper before the American Society of Naval Engineers. J. W. Jackson, before the Institution of Electrical Engineers, in discussing the general question of steam boilers working in electrical power stations, gives some interesting information in connection with the modern tendency to use a smaller superheater placed in a much hotter portion of the boiler than was formerly the practice. The Art of Locomotive Staybolts is the subject of a paper by C. A. Seley before the New York Railroad Club. When one considers that the breaking of a couple of staybolts may place an engine, the service value of which is from $25 to $100 per day, out of commission for a period of time, one easily recognizes the appropriateness of calling the handling of locomotive staybolts an art. The abstract of the paper by D. Landau on the Influences Affecting the Fundamental Deflections of Leaf Springs, from the proceedings of the Society of Automobile Engineers, is a valuable contribution to the scant literature of this highly specialized branch of engineering, while from the Journal of the Western Society of Engineers are taken interesting data on field and laboratory tests of gunite, cement mortar laid on by means of the cement gun.

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

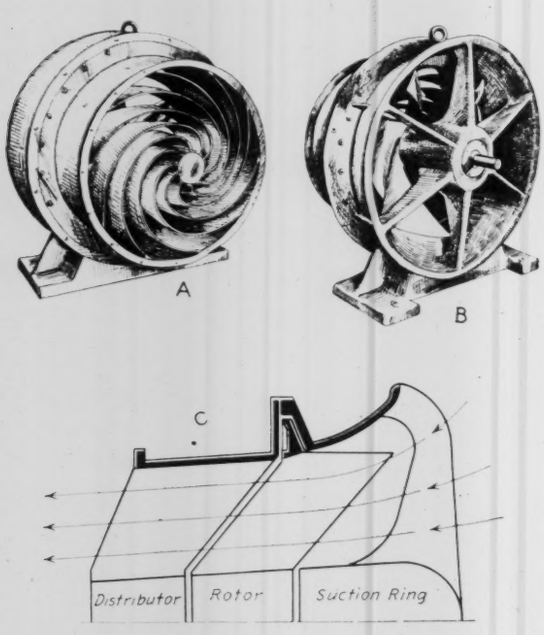
FOREIGN REVIEW

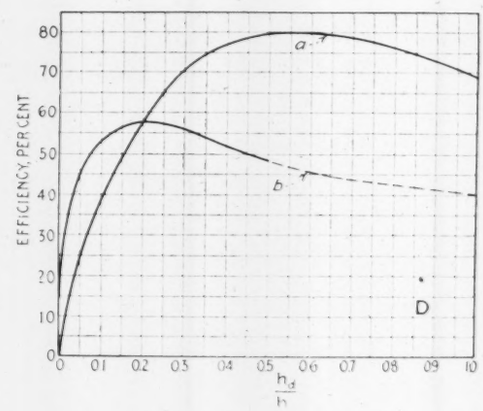
Air Machinery

THE SCHLOTTER BLOWER (*Schlotter-Gebläse*, Max Berlowitz. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 5, p. 49. 3 pp., 7 figs. *d*). The author states that for liquids and gases centrifugal pumps have been used nearly exclusively, while with helical wheels neither large pressures nor economic efficiency has so far been obtained. This is all the more regrettable because spiral pumps can be very conveniently installed and require much less space than centrifugal pumps, and also possess important advantages in that they are reversible and may be run at high speed. It now appears that a German engineer, G. A. Schlotter, has succeeded in building a spiral pump which can be used as a blower (Siemens-Schuchert Co. in Germany and abroad). It consists of a rotor, distributor and a cast-iron casing containing the rotor and provided with supports. The rotor has five vanes, the pressure surfaces of which are pure helical surfaces. In accordance with the use to which the apparatus is to be applied, they may be made either of some light metal or of bronze and, when run at high speeds, may be reinforced with supporting rings. The distributor has from eight to ten blades with a curvature opposite to that of the vanes of the rotor and, in the case of small units, is made of wrought iron; in larger units, of cast iron. When gases containing acids are to be handled, the rotor and distributor are galvanized, while for hot gases they are covered with a fireproof dressing. Ball bearings are used exclusively, and evidently need to be taken out to be cleaned and refilled with grease only once or twice a year. When hot gases are being handled, the bearings are water cooled. Since a bearing has to be provided in any case to take up the axle thrust, each blower can be used either vertically or horizontally and, if desired, can be in-

stalled at any angle of inclination. The vanes and distributors are shown respectively in Figs. 1, A and B.

The action of the blower is as follows: it gets air by suction from a semi-spherical zone, as shown in Fig. C, and presses it into a close bundle of vanes, easily rotating and converging toward the axis. The approximate path of stream lines is indicated by arrows and it must be observed that the air particles in their flow do not remain in the same section of the axis but perform a rotary motion all around the axis. Hence in the passage of air, shocks and eddies are avoided as much as possible, and practically all the energy applied at the driving end, with the exception of unavoidable losses due to friction in the bearings and air friction, is utilized in the normal operation of the engine. This blower therefore shows, under favorable conditions, a maximum efficiency of 80 per cent or more. The author considers it a very happy idea that a pressure piping or very flat diffusor is added under the blower, since the kinetic energy of the air can be transformed into pressure when leaving the diffusors. When a short exhaust angle is added, the exchange efficiency of the apparatus falls. Still more important, however, than the maximum efficiency of the apparatus is the fact that the efficiency curve of the blower is very flat, so that its construction produces an unusually high efficiency through wide ranges of loads from the highest back pressure up to free outflow.





Where $h_d = \frac{\gamma v^2}{2g}$ = the Dynamic Pressure Head in the Cross-Section of Outflow and h is the Total Pressure Produced by the Blower.

FIG. 1 SCHLOTTER BLOWER

For purposes of comparison two curves are given in Fig. D, one for the Schlotter blower (Curve a) and the other for a well-known centrifugal blower (Curve b), for the ratio $\frac{h_d}{h}$, where $h_d = \frac{\gamma v^2}{2g}$ is the dynamic pressure head in the cross-section of outflow and h is the total pressure produced by the blower. The construction of the blower permits it to be used for handling air and gases of any temperature as well as for handling gases containing dust and shavings. It is to be recommended particularly for places where saving in space and power is important and lower weight and easy installation considered to be of value.

The article does not give any numerical data of tests beyond the curves shown in Fig. D.

Internal-Combustion Engineering

HEAT TRANSMISSION IN THE GAS ENGINE (*Der Wärmeübergang in der Gasmaschine*, W. Nusselt. *Zeits. des. Vereines deutscher Ingenieure*, vol. 58, nos. 10, 11, 12, March 7, 14, 21, 1914, pp. 361, 414, 459. 13 pp., 13 figs. *etA*). In considering the cycle of a gas and oil engine, one is forced at the present time either to neglect entirely the heat exchange between the gases and the cylinder walls or at least take care of the expansion and compression element by assuming a polytropic shape of the curve. The purpose of the present investigation was to gain a clearer insight into the working processes of the internal-combustion engine and to investigate more thoroughly the laws of heat transmission from the hot gases of combustion to the cool cylinder walls. The author decided to divide the heat exchanged into that exchanged by radiation and that given up to the walls by convection and to establish for each case the corresponding laws, first determining in particular the influence of the gas temperature, surface, area, gas density and the composition of the gas. These tests were purposely not carried out in a gas engine, since experience has shown that an investigation of phenomena as complicated as those present in a practical gas engine does not permit of establishing a clear connection, such as would lead to the determination of a natural law. It is only by breaking up the entire phenomena into their composite parts and investigating the latter in special apparatus with that precision which is used in physical determinations, that one can gain the knowledge of the facts which admit of a general application. The author further explains that his experiments will give data practically applicable for all those technical installations where the cooling of hot gases is of importance, for example, heating apparatus, steam boilers, locomotive boilers, metallurgical furnaces, blast heaters, etc.

The main result of his investigations is expressed by the

author in the following postulate: *The coefficient of heat transmission is a function of time;* that is, if a certain amount of gas is enclosed in a vessel, the walls of the vessel remain cool and heat is brought into the gas (for example, by combustion), the instantaneous coefficient of heat transmission during the period of cooling depends not only on the temperature of the walls, temperature of the gas, composition of the gas and its density, but also on the time which elapsed after the beginning of the cooling. The shorter the time, the greater is the coefficient of heat transmission, all other quantities being equal. If, in a diagram, a coefficient of heat transmission be plotted over the gas temperature, a curve will be obtained which goes down with the decrease of gas temperature and approaches a final limiting value. If, in another experiment, the same gas be heated to a certain lower temperature, the curve in the new experiment begins not at the point which belonged to that temperature in the curve of the first experiment, but at a point of a higher coefficient of heat transmission. For the second experiment a curve is obtained which in the first part of the cooling period, lies above the curve of the first experiment. During the cooling, however, the two curves approach each other and finally coincide entirely as shown in Fig. 2A.

Further, for the sake of illustration, the coefficient of heat transmission is divided into that of radiation and of conduction (Fig. B), which shows that gases radiate heat at a pretty low temperature and the heat first radiated may be compared with that of conduction.

The conception of heat transmission is further thus elucidated by the author: As initially introduced by Newton, it was defined by the equation $dQ = \alpha F (t_1 - t_2) dz$ where dQ is the amount of heat given up by a body in the time dz while F is the area of the surface, t_1 the temperature of the surface and t_2 the temperature of the gas; α is also the amount of heat which a unit area of surface of a body gives up in a unit of time when the temperature difference between its surface and the gas is 1 deg. cent. The temperature of the surface is here assumed to be constant while the temperature of the gas is not the same at different points with respect to the body which requires its temperature to be specially determined. If the body undergoes the process of cooling in a gas mass, the space contents of which is large as compared with its volume, the gas particles are heated by it; they travel upwards along the surface of the heating body and, when they escape from the close proximity to the heated body, give up their heat by convection to other gas particles. Thereby a stationary temperature field is obtained, in that, along a line passing through the gas mass and starting from the surface of the heating body, the temperature, which at the start of the line, is that of the heating body, gradually decreases until it becomes independent both of the distance from the heating body and of the direction of the line. The stationary field temperature is to be supplied for t_2 in the above formula and is equal to the temperature of the surrounding medium. This determination of t_2 is therefore based on the assumption that the external, rigid limiting surface of the gas mass is large as compared with the surface of the heating body, so that differences in temperature potential at that limit may be neglected.

As a result the temperature of the gas in the neighborhood of the heating body must not be considered as equivalent to t_2. The outer shell of the gas may be considered as having shrunk together and reached a magnitude comparable with that of the surface of the heating element. Then the above established constant temperature t_2 disappears and in addition to the size of the enveloping surface, the location of the heating element with respect to that envelope acquires an important bearing on the heat transmission. The scientifically correct conception of the problem is made materially more difficult in this way. The influence of the shape and mutual position of the gas mass and the heating element requires, in carrying out experiments, an exact indication and competent selection of this magnitude.

If the surface of the enclosed body and its envelope are of the same magnitude, then, in order to make the experimental data applicable for technical purposes, two ways of formulating these data can be adopted: One way is that the heat is given up to the gas in accordance with the above equation by assuming $\alpha = \alpha_1$, and then from the gas to the envelope under the assumption of this latter process being carried on with the coefficient of heat transmission α_2, the envelope having an area F_2 and a constant surface temperature of t_3. If then t_1 is the temperature of the heating body and t_2 the gas temperature, then in the stationary state

$$Q = \alpha_1 F_1 (t_1 - t_2) = \alpha_2 F_2 (t_2 - t_3) \ldots\ldots\ldots [1]$$

if t_2 be eliminated, the heat exchange per unit of time is

$$Q = K(t_1 - t_3) = \frac{1}{\frac{1}{\alpha_1 F_1} + \frac{1}{\alpha_2 F_2}} (t_1 - t_3) \ldots\ldots [2]$$

Another conception may also be used, namely, by applying the Fourier theory of heat conductivity. If the gas does not expand with temperature and if the coefficient of heat conductivity of the gas is λ, then

$$Q = f(e)\lambda(t_1 - t_2) \ldots\ldots\ldots\ldots\ldots [3]$$

Here $f(e)$ is a linear magnitude which may be obtained by an integration of the Laplace differential equation with constant limits. The convection may be taken care of by inserting, instead of λ, a coefficient of heat conductivity determined by special experiments and being in the first place a function of the shape of the limiting areas of the gas mass.

The first method of procedure is in most cases more practical, since it gives values which are less apt to vary in different cases. It requires, however, the determination of the gas temperature t_2 since even if in formula [2] t_2 is finally eliminated, the values of α_1 and α_2 still depend on it. Here again there are two possibilities: First,

$$t_2 = \frac{\int t\,dv}{v}$$

where dv is a volume element, v is the total volume and t the local temperature; or t_2 may be defined as

$$t_2 + 273 = \frac{\int (t + 273)\,dG}{G} = \frac{V}{GR}\,p$$

where the integration is made over the gas weight G. In this equation p is the gas pressure.

These two definitions are, of course, not identical and different coefficients of heat transmission are obtained when one or another of these equations are used. The method of measuring the gas temperatures determines the selection of one or another of these definitions. If the temperature is measured by means of a thermometer, integration over

space will be used, and such method was used by the author for the determination of the coefficient of heat transmission in a tube. If, however, the average temperature is calculated from the pressures, the second definition has to be used as was the case in the experiments described below. The average temperatures in both cases will be found to be nearly equal.

The article describes in full the arrangement, apparatus

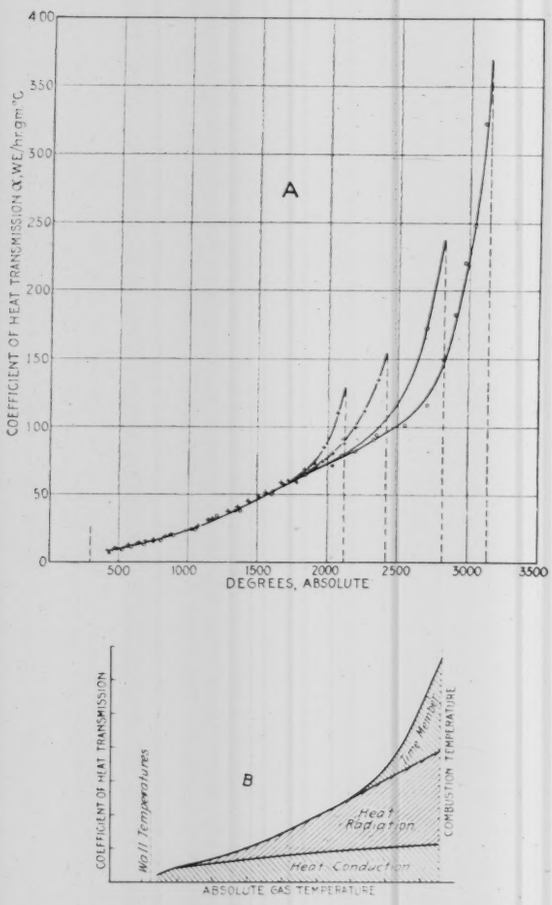


Fig. 2 Heat Transmission in the Gas Engine

and methods used by the author in his tests, and gives the results obtained in the form of tables and diagrams. Fig. A shows curves obtained from four experiments for the determination of the coefficient of heat conductivity, these curves being plotted in functions of absolute gas temperature. These experiments have been so arranged that after combustion, there should be present the same gas mixture of the same pressure at 15 deg. cent. temperature. This gas consists mainly of equal parts of carbon dioxide and carbon monoxide. Owing to different contents of carbon dioxide before combustion took place, different temperatures of combustion have been obtained, to wit, 2114, 2413, 2820 and 3141 deg. absolute. The cooling of the gas starts, therefore, at these different temperatures, and in each experiment it was found that as the cooling of the gas goes on, the coefficient of heat conductivity decreases.

An inspection of Fig. A shows that the older conceptions of the independence of the coefficient of heat conductivity from temperature and its proportionality to the difference in temperatures (in this view it was assumed that the amount of heat exchanged was proportional to the square of the difference of temperatures) are not correct, and the actual law appears to be far more complicated. A striking phenomenon is the strong alteration from $370 \frac{\text{cal.}}{\text{hr. m deg. cent.}}$ at the beginning of cooling to $7 \frac{\text{cal.}}{\text{hr. m deg. cent.}}$ at the end of the test. In accordance with the views held hitherto, one would expect that the curves representing the relation between the coefficient of heat conductivity α and the absolute temperature T would coincide in all the four tests, that is, that for the same average gas temperature, the coefficients of heat conductivity would be similar. Below 1700 deg. cent. this is actually the case and the diagram shows practically the same curve for all the four tests.

During the process of cooling the curve of coefficient of heat conductivity obtained from a test starting with the lower temperature of combustion, approaches that of the first test, in order to coincide with it at about 2000 deg. cent. The same happens in the case of the two other tests where still lower temperatures of combustion have been used. The author derives from this a new functional law which he calls *dependence of coefficient of heat conductivity on time*. If a gas be enclosed in a vessel, suddenly raised to a high temperature, and then allowed to cool through the walls of the vessel, one may obtain in the diagram for various gas temperatures a bundle of curves which has a certain envelope. In the beginning of the cooling the curve of heat transmission lies over the envelope. It approaches it during the cooling and coincides with it after a certain period of time for the rest of the duration of the test.

The author, therefore, divides the coefficient of heat conductivity into the two components. One member goes down to the envelope curve and for its magnitude depends on the composition of the gas, its density, gas temperature, temperature of the wall and shape of the vessel. The second component lies above that curve and in addition to the above mentioned independent variables, depends also on the time which elapsed since the beginning of the test. It is therefore called the *time member* and with the lapse of time gradually approaches zero value. In order that it should come into action it is necessary that some process, variable with time, should take place, that is, in some one spot the gas temperature should vary relatively to the rigid, heat exchanging wall. Since after a certain period of time, reckoned from the beginning of the experiment, the time element becomes equal to zero and the gas temperature acquires therefore a certain definite value independent of the initial temperature, it follows that the member which is independent of time is also a coefficient of heat transmission for a certain state of gas in which the gas temperature remains stationary. It is the intention of the author to determine this point later by special experiments.

The author goes further into a detailed discussion of the physical meaning of the time member. He bases his values on the Fourier fundamental law of heat conduction and applies his theoretical conceptions to the numerical consideration of an idealized example. (This part is not suitable for abstracting.) He proceeds then to the consideration of the separation of the heat transmission into two elements: heat transmission by radiation and by conduction. To do

this he proceeds in the following manner. With the same gas mixture two tests were made in the same bomb, the surface of which consisted in one case of a black material and in the other case of bright gold. At high temperatures, for the same gas temperature different coefficients of heat transmission have been obtained, while at low temperatures they were equal in both cases, which indicates that at high temperatures a certain amount of heat is radiated from the hot gases comparable with the heat taken away by conduction. Owing to the smaller absorption capacity for heat rays which bright surfaces possess, only a fraction of this radiated heat has been absorbed by the surface in that case while the black surface absorbs practically the entire radiation.

In order to be able to calculate from the difference of the coefficients of heat transmission the amount of heat radiated from the gas at a certain temperature, it is necessary to know the absorption capacity of the black and gilt surfaces. This was determined by a special series of tests which showed that the absorption capacity of a surface is a constant. Since, however, with the temperature the composition of the black radiation varies, it follows, from the fact of the absorption capacity being constant, that the absorption capacity of the gold surface did not vary with the wave length of the radiated heat, which made it possible to apply the values of the absorption capacity thus obtained in the explosion experiments described elsewhere. This being known, one has at hand all the information necessary for separating the coefficient of heat transmission into radiation and conduction scientifically without gratuitous assumptions. In Fig. B the coefficient of heat transmission taken from an experiment with the black surface has been plotted to scale with the absolute gas temperature as abscissae and divided into its component parts.

At the beginning of the tests the coefficient of heat transmission breaks up into three parts: the time element, the heat radiation and stationary heat conduction. After a certain period of time, the time element becomes zero so that the coefficient of heat transmission consists now of only two components, radiation and stationary conduction. A proof of the correctness of this conception may be seen in the fact that the radiation element may be represented by the ultra red waves of the natural period of frequency of a gas and that the remaining conduction obeys certain laws of heat conduction. The author proposes later on to give an analytical expression of these various elements.

Use of Diesel Engine for Driving Motor Cars (*Die Anwendung des Dieselmotors für den Antrieb von Motorwagen*, Arn. Lack. *Der Motorwagen*, vol. 17, no. 8, p. 165, March 20, 1914. Serial, not finished. *e*). The endeavor to replace in the automobile the present gasolene motor by some other type of oil engine is found mainly in those countries in which the price of gasolene has risen very much or where its supply comes mainly from abroad. There are quite a large amount of fuels to select from, such as benzol, kerosene and the other products of distillation of crude oil, as well as oil residues with specific weight of 0.83 to 1, in addition to which come the middle weight products of distillation of lignite, tar oils, gas coal and paraffin oils. Heavy lignite and coal tar oils are the last which can be considered for use in power wagon engines, since these oils do not easily burn without the addition of some more inflammable material and are especially difficult to handle at low temperatures. Further, tar oils are, as a rule, very viscous and their delivery to the fuel pumps and cylinders of the engine presents quite considerable difficulties.

Still more difficult than the question of fuel is that of the selection of a system of combustion and type of engine. The combustion may occur, of course, on the explosion cycle, Diesel cycle and middle pressure cycle lying between the two former, while the supply of fuel to the working cylinder and its distribution there may occur in an explosion engine by means of a carburetor or vaporizer, in the Diesel and middle pressure engine by an atomizer assisted by either the working air itself or a special source of air blast, or finally by means of proper mechanical atomization. The ignition may be either electrical or hot bulb in the explosion motor and due to the heat of compression in the Diesel type. The fuel supply in the automobile type of engine, if neither carburetor nor vaporizer are used, is rendered rather difficult on account of the high speed of the engine, while if a special blast of air for the atomization of fuel is used, the construction of the air compressor, which, being of small dimensions, has at the same time to run at a high-speed, presents also peculiar requirements.

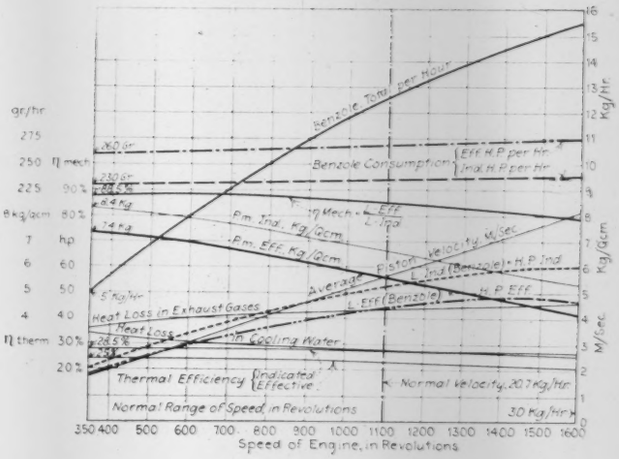


Fig. 3 Data of Tests of a Büssing Power Truck Engine

The above shows that the designer of the crude oil type of automobile engine has a fairly wide field to select from. He has, however, to consider certain special conditions, such as, for example, weight. Even if very high pressures may be admitted in the design, it is hardly possible to construct an engine of the Diesel type of as light weight as the standard automobile engine on account of the very high strains used in the former type. It appears that a greater saving in weight may be effected by using as high a speed of revolution or as high piston velocities as possible rather than by cutting down the weight of the machine parts. The operating conditions of the automobile engine are also more exacting than those of the Diesel engine type, first, because the engine is only poorly protected from the action of dirt and dust, and second, because it is only in exceptional cases that it has competent attendance.

The present investigation takes up the possibility of the application of the Diesel engine on automobile power trucks, and several considerations point to the conclusion that one may expect its application rather on the power truck than

on the passenger automobile, where the Diesel engine must satisfy the following requirements: high economy due to the use of a good engine burning cheap fuel, and independence from atmospheric conditions. The engine must be such as to be safely handled by a man of little technical knowledge, and must be therefore of simple and rugged construction and must have all the parts subject to great wear easily exchangeable. On the other hand, the power truck engine does not have to develop as high a speed as the passenger automobile and its weight may be somewhat larger, while it must also be able to develop a large starting torque. The author compares, in the curves included in the article and partly reproduced in the present abstract, the power truck and automobile engines using gasolene and benzol and the old engines working on the Diesel cycle. He gives in curves the results of tests of a power truck engine, two automobile engines and two Diesel engines.

Fig. 3 gives brake test data of a Büssing power truck engine, such as may be used in military trucks, the tests being made both with gasolene and benzol. This engine has not been designed to run at a high speed, as may be seen from the rapid falling off of the average piston pressure, which occurs when the number of revolutions is increased. Its normal range of speed is from 350 to 1100 r.p.m. Its mechanical efficiency is high and at the above speeds varies from 88.5 to 85 per cent; its fuel consumption is comparatively low. The weight of the engine for 35 effective h.p. normal output is only 330 kg. (696 lb.). The author also gives curves showing test data of a Renault and a high-speed Benz racing automobile engine, in which all friction losses are reduced as far as possible by proper design. The latter is a special type of engine where extraordinary measures have been taken to raise the specific output; its mechanical efficiency varies from 91 to 81 per cent, while the average piston speed exceeds 12 m. per sec. Other curves show results of tests on a 5-h.p. small Diesel engine built by Diesel and Company in Munich. The average indicator piston pressure in this engine, at a speed of 800 r.p.m., goes up to 9.12 kg. qcm., which in this type of engine corresponds to a considerable load. The mechanical efficiency at 600 r.p.m. was only 58 per cent and at the average piston velocity of 3 m. per sec. (9.8 ft. per sec.) only 66 per cent, not including the power used in the air compressor. This efficiency is low as compared either with the automobile engine or with the normal type low-speed Diesel engine, and the fuel consumption is invariably affected by this fact. The weight of this small Diesel engine was for the purely motor parts 150 kg. (370 lb.) and with the accessories 360 kg. (790 lb.). A 30 effective h.p. engine has been built for automobile use on the same lines as this small engine working on the four-stroke cycle. It is now in the German Museum in Munich and its tests have not given any very encouraging results.

TABLE 1 MAIN DATA OF COMPARATIVE TESTS OF A BENZOLE AND A GASOLENE ENGINE

Output, E.H.P.		Final Compression Pressure at Maximum Output, Atmospheres	Average Volume of Piston Displacement per Sec. per I.H.P. Liters		Fuel			Consumption per E.P.H-Hr., G/Lb.			Heat Consumption, E.H.P-Hr. at Normal Output, WE/B.t.u.	Efficiency, Per Cent		Cooling Water, Temperature Deg. Cent./Fahr.		Consumption per E.H.P-Hr., Kg./Lb.
Normal	Maximum		Normal Output	Maximum Output	Kind	Specific Weight	Approximate Heating Value, WE per Kg./B.t.u. per Lb.	Half Load	Normal Load	Maximum Load		Thermal	Mechanan	Entering	Leaving	
4	5.3	5.5 to 7	9.0	7.0	gasolene	0.72 to 0.74 at 13 deg. cent.	10,500/18,900	460/1.01	320/0.70	310/0.68	3360/13,340	19	about 80 at maximum output	10/50	50/122	35/77
6	7.5		8.6	7.0				470/1.03	320/0.70	300/0.66	3360/13,340	19		10/50	50/120	35/77
10	12		7.3	6.1	benzole	0.87 at 18 deg. cent.	9600/17,200	470/1.03	315/0.69	325/0.71	3020/11,990	21		.....		
20–25	25–32.5	12	6.2	4.9				315/0.69	235/0.51	220/0.48	2260/8972	28	about 85 at maximum, 80 at normal output	10/50	50/122	

TESTS OF GASOLENE AND BENZOL ENGINES (*Versuche an Benzin und Benzol-maschinen*, Ph. Stauf. *Zeits. des Bayerischen Revisions-Vereins*, vol. 18, nos. 1, 2, 3, pp. 1, 13, and 23, January 15 and 31, and February 15, 1914. 7 pp., 9 figs. *de*). The investigation was made to determine the comparative properties, such as efficiency, fuel consumption, consumption of cooling water, etc., of a gasolene and a benzol engine, the main results of the test being present in Table 1. From this it appears that the benzol engine came out better than the gasolene engine, although it must be borne in mind

that it was also considerably larger. Nevertheless the table of tests on a small benzol engine published in the same periodical, Page 60, 1908, would appear to indicate that the fuel consumption in the benzol engine was generally better than in the gasolene engine, owing to the higher compression pressure used in the former. It appears that even in the 10-h.p. benzol engine test in the present case, compression pressure was not high enough and therefore its fuel consumption was comparatively too large. As regards the fuel cost per unit of output in Germany the price of gasolene was assumed to be 38 marks per 100 kg. and that of benzol 30 marks, while the consumption at ½, ¾ and full load was in the case of the gas engine 470, 370 and 320 grams per effective h.p-hr. respectively, and those of the benzol engine, 400, 300 and 270 grams. In accordance with this, the fuel cost in the first place is taken at 18, 14 and 12 pfennigs per effective h.p. and in the second case at 12, 9 and 8 pfennigs. These figures are of course only general, since they would vary with the state of the engine and the market price of the fuel.

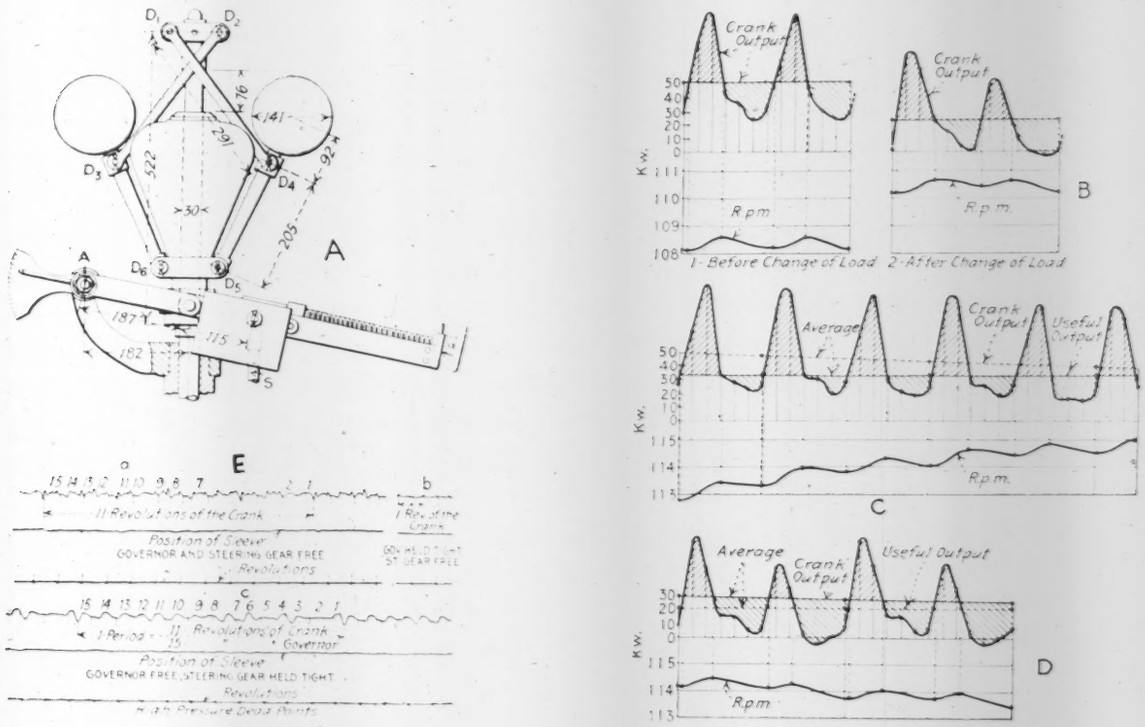


Fig. 4. A, B, C, D, E Governing of Engines

Machine Design

On Governing of Engines (*Über Kraftmaschinen-Regelung*, M. F. Gutermuth. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, nos. 11, 12, 13, pp. 408, 441 and 497, March 14, 21 and 28, 1914, 15 pp., 28 figs. *etA*. Abstract not finished; will be continued in a future issue). The theory of the governor process shows that when the resistance of engines varies, the variations in the load and changes in the velocities produced thereby depend not only on the degree of irregularity and sensitiveness of the governor, but also on the resistance to displacement of the actuating gear, and are further materially influenced by the regulation properties of the type of engine under consideration, that is, whether it is a steam or gas engine, Diesel engine, steam or water turbine. Further, there is the influence of the magnitude of rotating masses and, in the case of multiple expansion steam engines, that of the receiver steam also; in addition, the governing of engines is also dependent on the kind and type of the variations of resistance, which is, for example, in the case of mechanical transmission, materially different from that in electrical operation. In the latter case, the governing process is affected also by the type of dynamo (whether direct or alternating current) and by the changes in the electrical state of the dynamo which occur when the load is varied, and which produce a certain electrical regulation, in its turn differing with the electrical excitation of the dynamo and the way it is connected with the lighting net (with or without storage batteries). This manifold dependence of the action of the governor or the system and operating conditions of the prime mover determines the variable behavior of a governor under similar alterations of load in different practical cases, which often makes necessary a time-consuming adjustment of the governor and empirical testing of its action. The present investigation is devoted to this problem. The tests were made mainly on a horizontal compound steam engine with a bore of 300 to 450 mm. (11.8 to 17.7 in.) and stroke 600 mm. (23.6 in.) with a Kuchenbecker valve gear on the high-pressure cylinder and a piston valve of the Wheelock type on the lower side of the low-pressure cylinder. The average speed was 110 r.p.m.; from the flywheel, by a belt transmission, was driven a Schuchert shunt direct-current, 140-volts dynamo which together with the storage battery, supplied current to the lighting net of the college buildings. Comparative tests

of the action of various governors have not yet been completed, and the present tests have been carried out with the Steinle-Hartung weighted governor, the mass and weight details of which can be seen from Fig. A. The governor shaft was driven by a bevel wheel gear with a ratio of transformation of 15 to 11 so that its speed was $100 \times \frac{15}{11}$ or 150 r.p.m.

For loading the electrical generator a large resistance of constantan wire was used which at maximum load took 500

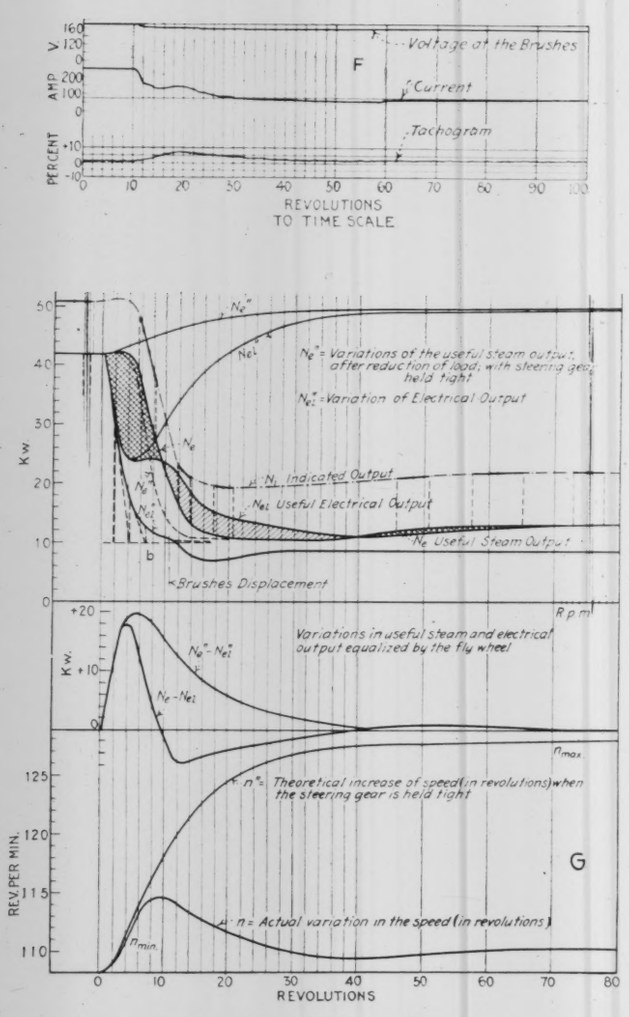


Fig. 4, F, G Governing of Engines

amperes at 140 volts, a special switch being provided for varying the load within any desirable limits by a single movement of a handle. In certain tests the storage battery which served for lighting the high school was also placed in circuit. In all tests the engine had been in its normal state of operation before the alteration of load took place. As a rule the exchange between the work put in, taken out and consumed in the flywheel during the period of regulation does not fundamentally differ from that during the normal operation of the engine but during the variation of the load the comparatively large difference between the work put in and that taken out leads to correspondingly large variations in the kinetic energy of the flywheel masses and thereby to large variations in the peripheral speed and number of revolutions. Figs. B, C and D show the relation existing between the crank peripheral speed, indicated steam power and electrical power taken out, for a single revolution, before, during and after the variation of the load, while the amounts of work contained in, and discharged from, the flywheel masses are represented by sectioned areas, the corresponding speed alterations being shown in the wave-shaped speed diagram. The abscissae represent the crank paths or time in seconds and the ordinates output in kilowatts, so that the work areas represent kw. per second. The velocity ordinates represent the number of revolutions per minute. Diagram I, Fig. B, refers to a revolution during the normal state of operation of the engine previous to the variation in load, while diagram II shows what happened after the change in load. The positive and negative work areas on the diagram are respectively equal during one and the same revolution and the speed curves show the oscillation, rhythmically following one another and thus exhibiting the degree of irregularity δ, of motion, the average peripherical velocity being greater after the reduction of load that it was before. This variation in speed determines the degree of irregularity of the governing δ_1. Fig. C represents the variation of indicated output, resistance and peripheral speed for two working periods occurring under the influence of the governor: the first diagram for the period of increasing and the second for that of decreasing average speed. These diagrams differ from those obtained during the normal period of operation in that there is no equalization between the work of the steam and the resistance work, and, on the contrary, in diagram C the first predominates and in diagram D the second. The equalization of work occurs through the variation in the kinetic energy of the flywheel masses, the average speed of which decreases with excessive work of resistance and increases when the work of the steam is excessive, as may also be seen from the velocity diagram. As regards the degree of precision in the determination of these details of the complicated governor process, it must be borne in mind that the error of observation and measurement in the determination of electrical output, when properly calibrated instruments are used, is only very slight, but may be considerably larger with respect to the indicated and effective steam output. Errors of at least 1 per cent are possible in the measurement of the indicator diagram by means of a planimeter, and in addition, there is the possibility of discrepancy in the calibration of the indicator spring, so that the maximum accuracy of the measurement of the indicator output cannot be assumed to be closer than 2 per cent, while it may be still less exact for small outputs. The mechanical efficiency of the steam engine is further influenced during regulation by the variable speed of revolution and abnormal distribution of steam between the high and low pressure cylinders which occur at such times.

As regards the diagrams of lift of sleeve and the regulating power of the governor (Fig. E_a), it may be remarked that even during the normal operation the governor does not remain stationary but keeps up a series of little jerking motions which are, however, independent of the speed of rotation of the crankshaft, and out of accord with those which would theoretically be expected.

These irregular or jerking motions of the governor, as one may be inclined to assume from their periodical occurrences, may be rather ascribed to forces acting intermittently, and caused by the play in the wheels of the governor and actuating gear shaft drives and back pressure exerted by the steering gear drive on the governor. These periodically recurring variations in the adjusting gear can affect either favorably or unfavorably the regularity of the governor during one governor operation. The following methods were used to determine the influence of the separate action of each of these elements during the normal operation of the experimental engine: In order to determine the influence of the governor drive on the sleeve motion, the steering gear was held rigid while the governor was allowed perfect freedom of motion. On the other hand, to determine the influence of the return back pressure of the steering gear, the governor was held rigid while the steering gear was given freedom of motion. The diagram of the sleeve motion, Fig. E_c, with the steering gear held rigid, shows a certain regularity of action which may be seen in the fact that after each 11 turns of the crank, there occur equal periods of oscillation, evidently due to the ratio of transmission of the governor drive being 15 to 11, while the same pressure in the teeth occurs after each 11 revolutions of the steering gear shaft. It appears, therefore, that the oscillation phenomena connected with the steering gear drive shaft and governor spindle are caused only by the inexactness of the cut of teeth or wedging of gear wheels, since otherwise, that is, with an absolutely uniform gearing, the periodically occurring difference in the transmission of motion would not take place. As far as the work of adjustment is concerned, it does not appear to be affected by the frictional resistance of the governor and its adjusting gear, but its degree of irregularity is correspondingly reduced and depends only on the resistance to adjustment of the steering gear, if the mass action of the governor be considered as having constant influence. The back action of the steering gear obtained with the governor held rigid and steering gear free, as shown in the curve (Fig. E_b), appears to be of secondary importance as compared with the influence of the governor drive. It soon produces very slight (though regularly occurring with each revolution) jerkings which cause a temporary sluggishness in the adjusting motion. Fig. F represents the variations in electric potential and current, speed of rotation, sleeve motion and tension in the governing rod which occur when the load on the engine is suddenly reduced from 42 to 12.6 kw. The mutual relations between the amount of power put in at the steam end and that taken out electrically, as well as the variations in velocity during the process of reduction of load are shown in the diagrams of Fig. G, where the steam output is determined from indicator diagrams. In considering the curves of the governor process shown in Fig. G, of first importance is the mutual variation of the average steam output and electrical resistance during the crank revolutions which follow one another. In this diagram, the loss of the steam engine and dynamo are subtracted from the ordinates of the curve N_i which shows the indicated output; the curve N_e is thus obtained representing the effective or useful steam output required for the generation of the electrical output N_{el}. Since during the process of load alterations the two amounts of output do not coincide, sometimes the steam output and sometimes the electrical output predominating, the amounts of excessive power which are shown by the sectioned areas must be either taken up or given out by the flywheel masses, a process which determines the magnitude and kind of the average speed alterations as indicated in the lower curve in Fig. F. The two output curves N_e and N_{el} characterize to a certain extent the process of variation of the work put in and taken out, the difference in which causes the variations in speed during the change in load, while equalization can occur only when a new state of normal operation is established. Side by side with these variations in speed which determine the degree of sensitiveness ε_r of the governor, and disappear after a certain small or large number of crank revolution, there are also variations in velocity which are caused by the variations of tangential forces acting on the crank and which determine the degree of irregularity δ_s of the crank shaft and flywheel, and which appear as continually occurring variations of the peripheral velocity under all conditions of operation. As regards further the steam and electrical output during the process of regulation, one may state that within the limits of the degree of irregularity of the governor δ_r the variation of useful steam output may be directly determined from the curve of the sleeve lift and of the speed, while the variation in the electrical output with the system of loading such as represented here may be determined directly from the velocity curve.

Machine Shop

On Heat Process Occurring in Cutting Metals, and Best Speeds of Cutting (*Über die Wärmevorgänge beim Spanschneiden und die vorteilhaften Schnittgeschwindigkeiten*, H. Friedrich. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, nos. 10, 11, 12, pp. 379, 417, 454, March 7, 14, 21, 1914. 14 pp., 22 figs. *etA*). The present investigation was proposed to cover the heat phenomena in cutting metals and their relation to the most advantageous speed of cutting. The investigation was started partly along theoretical lines and partly practical. The theoretical part covered (*a*) the derivation of an equation expressing the most advantageous speed of cutting from its functional relation to the heat distribution in the metal cut and the tool used; (*b*) the derivation of the equation for the most advantageous speed of cutting on the basis of the temperature of the shaving, and (*c*) the comparison of similar heat processes. The practical part of the investigation covers tests for the determination of the constants of materials, as well as brake tests and tests of high-speed lathe with multistage gear drive tests, cutting speed, and the testing of the material used; further, heat determinations at equal cross-section of shaving and variable speed of cutting, and at a normal speed of cutting and variable cross-section of shaving.

The importance of the heat process in the cutting of metals did not become really serious until the introduction of high-speed steel. In the cut of metals, one may distinguish the action of the tool and of the piece cut and the motion phenomena in the material cut, the resistance occurring thereby, the power used, and the heat process. The first and second classes of phenomena have been sufficiently investigated while the pressure used for cutting a shaving of certain dimensions and the heat developed therein have not yet been sufficiently investigated. The action of the tool on the piece of metal machined consists in upsetting, bending and cutting of the material of the shaving. The stresses in the material which take place during these processes are

therefore comprised of compression bending and shear stresses. In addition, there is the wedge action of the tool, the friction of the cutting edge, back edge and breast part of the steel which depends on whether the cutting edge must press into the material or whether the shaving breaks off from the metal piece before it comes in contact with the cutting edge of the tool. Since it is impossible to treat theoretically the resistance to cutting, under the consideration of all these influences, one has assumed hitherto that the specific resistance to cutting for a given material is invariable, which is, however, untrue as shown by experiments of recent date. This makes it necessary to investigate the power used in cutting the shaving in connection with the heat processes occurring thereby.

In experiments on resistance to cutting it was found that the cutting pressure per unit surface of the cross-section of the shaving is not invariable and that it becomes smaller when the cross-section of the shaving becomes larger, or that the consumption of power for a given amount of shaving is smaller when the shavings are thick than when they are fine. This might be derived also from the following consideration. If a piece of metal is to be cut into small shavings, and another piece is to be cut first into thick shavings and then into fine ones, in the first case there is only the labor of cutting, while in the second case there is both that of cutting and of splitting, and one may therefore assume that for an equal amount of shavings the work of cutting is not the same in the case of fine or thick shavings. The specific pressures of cutting can therefore also not remain constant. The work of cutting per unit quantity of shavings is the larger the greater the area of surface cut off, or the surface produced by splitting. If the work of cutting is divided into work of friction and that of changing the form of the material, the second increases with the cross-section of shavings and the first with the area of the surface of shavings. The assumption that the total work is proportional to the surface is therefore confirmed by experimental data. One can therefore consider the resistance to cutting P in accordance with the equation

$$P = kf + w\beta$$

as consisting of two parts of which the first is proportional to the cross-section of the shaving f and the second to the surface of the shaving β, while coefficient k represents the strength of material and w is a function of the friction of the surface of cutting. In cutting strong or hard materials such as metals, the resistance of the metal is of prime importance, while in handling soft stuffs, such as leather, the total resistance is mainly a function of the resistance in the surface of the cut.

The speed of cut could be raised as high as desired if it had not been proved by circumstances that at too high velocities of cut the cutting edge becomes dull owing to excessive heat. The physical condition for the most advantageous speed of cutting may therefore be expressed as follows: *The temperature of the cutting edge must not exceed a certain definite value.* There are several circumstances which determine when this maximum admissible temperature is reached, and that depends on the amount of heat generated in cutting the metal, the distribution of the heat and the rise of temperature produced thereby. The amount of heat generated in cutting is a function of the work of changing the form of the material cut and the work of friction at the cut. The heat is therefore liberated inside the shaving and at the surface of the shaving, and the amount liberated in a given period of time is proportional to the work of cutting consumed in that time. The distribution of heat starts from the place of cut at which the heat generated may be considered as heat freely liberated and is distributed through the shaving, the tool, the piece machined and the surrounding medium. The rise of temperature is at its maximum at this place of cut. At the beginning of the cutting this rise of temperature is fairly rapid, but after a certain time it reaches a certain normal state if the speed of cutting, resistance to cutting and other variables remain constant. The temperature at the place of cut is, therefore, what under given conditions determines the admissible speed of cut, but it cannot be determined by direct measurement and, therefore, the permissible speed of cutting is later on in this investigation expressed in a different manner than as a function of the rise of temperature.

At the basis of the present investigation and the heat measurements were laid certain physical considerations. On the basis of the distribution of the heat generated in cutting and shaving, an equation has been derived for the most advantageous speed of cutting, this equation being in accord with another equation derived from the consideration of the work consumed in cutting. At the velocities of cut determined in accordance with this equation, the rise of temperature of the shavings for various cross-section of shavings is accepted to be approximately constant, which is explained through the processes of heat distribution and has been confirmed by experiments. Further, an equation has been derived, and found to be true by experiments, expressing the variations of temperatures of shavings at constant cross-section of shavings and at various places of cut. Owing to the variable heat conduction which takes place with various forms and formations of shavings, as well as owing to the variations in the specific heat and coefficient of heat conductivity of various materials, the equation derived for this case can be considered as being only approximately correct. But it has been found that it gives values in fairly good accord for practical processes with values obtained experimentally.

The author closes with the following important conclusions: The rise of temperature for shavings of equal cross-section, but different speeds of cutting, increases with the speed of cutting, since at the slower speed of cutting the unit of the surface of the shaving is enabled to give off more heat to the surrounding medium. The variation of the rise of temperature with varying speed of cutting is expressed by means of a special equation, determined from the heat given off to the surrounding medium and that taken up by the shavings, and experimental results have confirmed the correctness of the conclusion. In order to avoid excessive heating of the tool, the temperature of the shaving at various cross-sections of the shaving and at various speeds of cutting must not exceed a certain value. As a condition for constant temperature of shaving may be conceded the conduction of equal amounts of heat per unit of time and per unit of area of the shaving surface. In this way two equations are obtained, one for the work used in cutting, and the other for the distribution of heat in the shaving, from which the corresponding speeds of shaving may be calculated. Experiments have shown that the speeds of cutting determined

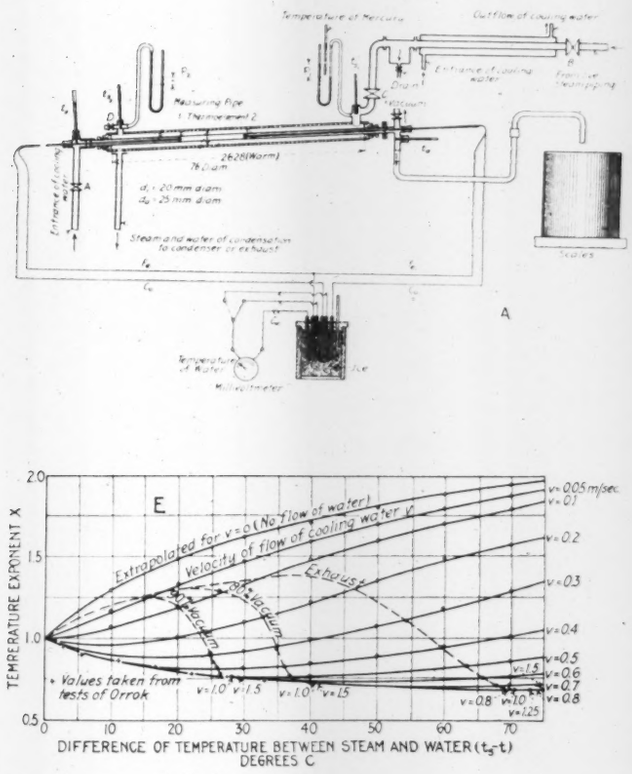
in this manner produce constant temperatures of shaving. The efficiency of the lathe increases rapidly with increased cross-section of shaving. It acquires its maximum with such metals as were used in these tests when the cross-section of shaving is from 2 to 4 qmm., and for larger sections of shaving remains nearly constant. When the largest and smallest ratios of gear transmission are used, the efficiency is somewhat lower than with the average gear transmission. It is better to avoid shavings of less than 1 qmm. cross-section.

Steam Engineering

Tests on Heat Transmission from Steam to Cooling Water (*Versuche über die Wärmeübertragung von Dampf an Kühlwasser*, K. Hoefer. *Zeits. für das gesamte Turbinenwesen*, vol. 11, no. 8, p. 113, March 20, 1914, 3 pp., 10 figs. *et.A*). The article describes extensive tests made in the mechanical laboratory of the Technical High School of Berlin on heat transmission from steam to cooling water. The complete account of the tests was published in *Mitteilungen aus dem Maschinen-Laboratorium der Kgl. Technischen Hochschule zu Berlin*, Vol. 5. The main purpose of the tests was to establish the manner in which the amount of heat transmitted from steam to water in cooling pipes depends on the difference in temperatures of these two media. It is usually assumed that the amount of heat transmitted is directly proportional to the difference in temperatures, while there are also indications that it may vary as the square of the difference in temperatures. On the other hand, Mr. Orrok in his paper on The Transmission of Heat in Surface Condensation, published in *Transactions, Am. Soc. M. E.*, Volume 32, Page 1139, has found from extensive experiments that the amount of heat transmission is

$$dW = cdF\ (t_s - t)^{7/8}$$

where dW is the heat transmitted over surface dF, while t_s and t are the temperatures of steam and water respectively, c being a constant. The present tests had for their purpose, the elimination of these contradictions and the establishment of the temperature exponents for various conditions. Fig. A shows the experimental arrangement used. The water flows through a brass pipe having an inside diameter of 20 mm. (0.8 in.) and an outside diameter of 25 m. (1 in.) with a length of 2628 mm. (104.4 in.) and was heated on the outside by steam. Particular care was taken that a uniform stream of steam should be present along the entire length of the pipe so as to prevent stagnation of air. The temperature of the water in the pipe was measured by two displaceable iron-constantan thermo-elements, the voltage of these thermo-elements being measured by a very sensitive voltmeter, which permitted estimates to 1/10 deg. cent. Since, in the same cross-section, the temperature of the water at the center was lower than that nearer the edges, in the determination of the average temperature in the cross-section a special device was used to produce eddies near the soldered place of the thermo-elements. Three series of tests were made at atmospheric pressure, and with vacuums of approximately 80 and 90 per cent. In the first two series of tests the velocity of flow of water was raised by small stages from 0.05 to 1.9 m/sec. (1.96 to 74 in./sec.) and in the test with 90 per cent vacuum from approximately 0.3 to approximately 1.5 m./sec. (11.8 to 59 in./sec.). Figs. B and C show the temperature curves which would have been obtained had the transmission of the heat been proportional to the difference in temperature and it can be seen at a



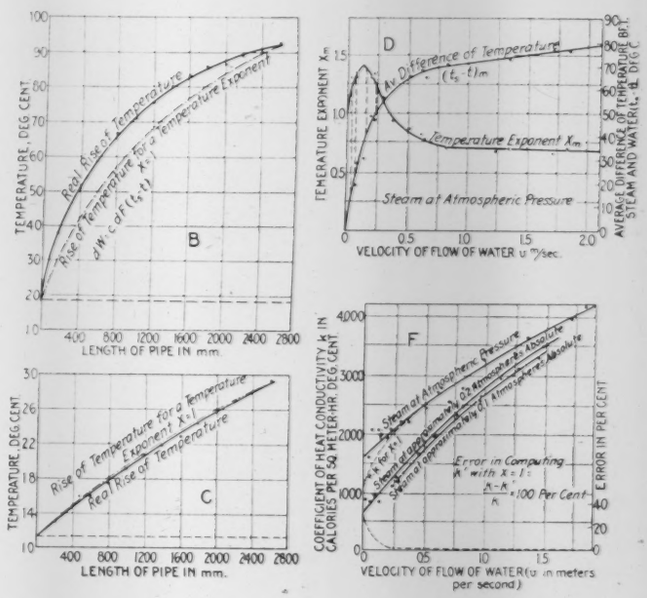


Fig. 5 Heat Transmission from Steam to Cooling Water

A Experimental Arrangement; *B* and *C* Temperature Curves for Transmission of Heat assumed to be Proportional to Difference in Temperature; *D* Average Temperature Exponent as a Function of the Velocity of Flow of Water; *E* Temperature Exponents for all Velocities of Flow of Water and Differences in Temperature; *F* Coefficients of Heat Transmission Actual and Assumed (for $x=1$) compared.

glance from a comparison of these curves with those obtained experimentally that there is no such proportionality and that the temperature exponent is, therefore, not equal to 1. In the test represented by Fig. B the exponent must be larger than 1; in the test represented by Fig. C it must be smaller. By means of a graphical logarithmic process the average temperature exponent x_m has been determined for each test and Fig. D shows this average exponent as a function of the velocity of flow of water for the three series of tests. It is evident that the temperature exponent is not constant and that it varies both with the velocity of flow of water and with the difference between the temperature of steam and water. In order to separate the influences of these two factors, a simple graphical process was again used and Fig. E shows the temperature exponents x for all velocities of flow of water and differences in temperatures between water and steam. The important result thus shown is that *the exponent varies within wide limits,* viz., *from 0.7 to 1.9 for a difference in temperatures of 70 deg. cent. (126 deg. fahr.)* All the curves for $t_s - t = 0$ coincide at certain point $x = 1$. The particles of water which flow along the walls of the pipe have a temperature which is only very little different from the temperature of the pipe walls; the closer the difference in temperatures approaches the value zero (and it appears probable that $t_s - t$ at the pipe wall is very near the value zero), the closer x approaches the value one. From this it follows that the *heat transmission from the pipe wall to the outermost layers of the cooling water is proportional to the difference in temperature for all velocities of flow of water.* The fact that the temperature exponent, as referred to average water temperature, may have as different values as are shown by the experiments is doubtless due to the fact that the distribution of temperatures in a given cross-section may be very different in various cases. Just how this distribution of temperatures occurs numerically cannot be established from the present experiments, but it has been established that there are differences in temperatures at various points of the same cross-section of water in a cooling pipe. At lower velocities convection phenomena may also play a certain part, and, since the distribution of temperatures is the cause of the difference in the values of the exponents, it appears probable that the diameter of the pipe has also a certain influence on the value of the exponent.

The results of this test are to a certain extent not in agreement with the results obtained by Mr. Orrok, who found that the temperature exponent was independent of the differences in temperatures, and for all velocities of flow of water from 0.6 to about 2.6 m/sec. has a value of $x = 7/8$. On the other hand, the data obtained by Mr. Orrok confirm and add to these tests as they have been made for small differences in temperature and high velocities of flow of water.

Further, the present tests have permitted the determination of the coefficient of heat transmission k. Fig. F shows its values as a function of the velocity of flow of water v. In order to show the amount of deviation if the coefficients of heat transmission were calculated under the assumption that the temperature exponent has a constant value $x = 1$, a curve was plotted in Fig. F. For velocities of flow of approximately 0.4 m/sec. (15.7 in/sec.) the two curves coincide, since in this case x is actually equal to 1, and even for larger velocities of flow of water, there is practically no difference between the two curves. This fact is very important for the calculation of condensers, since it enables one to use the simple formula made possible by assuming that $x = 1$, namely

$$F = \frac{Q}{k} \ln \frac{t_s - t_e}{t_s - t_a}$$

where F is the cooling surface of the condenser in qm, Q is the amount of cooling water per hour in kg, t_e is the entering temperature of cooling water and t_a the temperature of cooling water flowing out. Only in the case of very low velocities of flow of water the actual conditions must be taken into consideration and the more exact formula used. For atmospheric pressures the value of the coefficient of heat transmission may be expressed as

$$k = 1600 + 1743.v^{0.82}$$

and for a vacuum of 80 per cent

$$k' = 650 + 2090.v^{0.82}$$

The exponents of v agree with each other fully and lie between 0.72 and 0.91 (as *Zoennecken* has found in his tests) and therefore ought to be very near their actual values. The difference between k and k' is doubtless due to the decrease of the coefficient of heat transmission from the steam to the wall, when the density of the steam decreases. Numerically these values cannot yet be given since the functional relation between heat transmission and density of steam is unknown.

Co-Working of Steam Boilers Running on Different Pressures (*Das Zusammenarbeiten von Dampfkesseln verschiedener Spannung. Zeits. für Dampfkessel und Maschinenbetrieb,* vol. 37, no. 11, p. 129, March 13, 1914. 3 pp., 6 figs. *d*). At the 43d meeting of the delegates and engineers of the International Association of Boiler Inspection Societies, which took place in Moscow, Werthwein of Barmen presented a report on the simultaneous working of boilers working with different pressures. The general development of power plants requires the application of higher and higher steam pressures, at the same time as the installation of new boiler units. As a result, especially in plants which are not new, it often happens that side by side with the new boiler group working with high pressures there are also in operation a number of the older boiler units of lower pressures. The steam of the latter is in such cases used mainly for heating, cooking, preheating of water and other purposes where high pressure is not desirable or is not of material advantage. The size of the new boiler elements of large pressure is in most cases designed in a manner such that there shall be sufficient steam not only for all available power purposes, but also to a certain extent for those demands which are primarily satisfied by the older units, and the devices which insure the collaboration of the two kinds of boilers must be arranged in a manner such that on one hand all the advantages of the high pressure and available heating surface of the high-pressure boilers shall be thoroughly utilized, while on the other hand all danger for the low-pressure boilers shall be eliminated. As far as the author is aware, there is only in Germany legislative rules governing such cases of running together boiler groups of various pressures.

The Prussian regulations of 1902 were as follows: (*a*) The steam piping from high-pressure boilers must be provided with automatically acting devices (such as reducing valves, pressure regulators, etc.) by means of which

steam flowing into the collector piping shall be reduced to the lower pressure level of the other boilers. (*b*) In front of this pressure reducing device, that is, on the side of the high-pressure boiler, there shall be a cut-off valve, if possible, such as can be operated from the floor level. (*c*) The common piping shall be provided with a small scale manometer and such number of safety valves as will maintain the pressure prevailing in the piping not in excess of that prevailing in the low-pressure boiler connected thereto. (*d*) Each of the steam boilers connected to the common piping must be provided with a slow-acting long-stroke safety valve. (*e*) Each boiler must be arranged so that it will cut off from the piping. (*f*) The feed piping of boilers of various pressures connected to a common steam piping must be kept separate.

These rules have been somewhat modified by the German law for land steam boilers of 1909 and at the present time only the first section of the above regulations is in force. Both groups, high and low pressures, will give off their steam into a common piping. In the pipe connections from the low-pressure boilers to the common piping, pipe isolating valves are installed in a manner such that the cones of the valves shall be lifted by the steam flowing from the low-pressure boiler toward the collector piping. The pressure in the collector piping must therefore be somewhat lower than that in the low-pressure boiler connected thereto and the pressure of the steam acting from the high-pressure boiler must have been correspondingly reduced by means of reducing valves or in some other manner. As regards the pipe isolating valves, the most simple construction was preferred at first, such as valves with loose ball. It was soon evident, however, that in several respects these valves were unsuitable, especially where the steam engines received their steam from the collector piping and also where only the high-pressure boilers supplied steam to the engines, while the steam from the collector piping was used for other industrial purposes, such as heating or cooking. In all such cases the pipe isolating valves produced a noise due to the valve ball striking against its setting, until finally the constant strokes destroyed both the seat and the ball, while the noise was so unpleasant for the boiler attendant that the ball was often removed and the valve became absolutely useless. To avoid these inconveniences, it was proposed to insert into the steam piping special steam collectors and to use pipe isolating valves of such a construction as to avoid the production of the noise.

Schaffer and Budenburg in Magdeburg used the pipe isolating valve shown in Fig. 6A, with the horizontal axis coming out from the casing through a stuffing box. To the stuffing box end of the axis is fixed a lever having on one end a tension spring and on the other end an oil brake. If variations of pressure occur in the piping the valve cannot fall off, owing to the damping action of the spring and brake. In many cases the spring alone, without the brake, is quite sufficient. Dreyer, Rosenkranz and Droop in Hannover have placed on the market a pipe isolating valve shown in Fig. B, with the valve cone suspended on a spring and therefore sitting much lighter than an unbalanced cone. Although a valve of this type has been placed on a collector piping from which steam was supplied to a rolling mill engine and a steam hammer, no knocking in the valve has been observed. Franz Seiffert and Co. in Berlin used a pipe isolating valve (Fig. C) where the valve cone is connected with a balanced brake piston.

All these valves have succeeded in eliminating most of the troubles occurring with the ordinary type pipe isolating valve, but in order to make possible the working of two boilers of various pressures on the same collector piping, without any undesirable occurrences and with full safety for the low-pressure boiler, additional devices have to be installed, and the above mentioned Prussian regulations indicate what these devices should be.

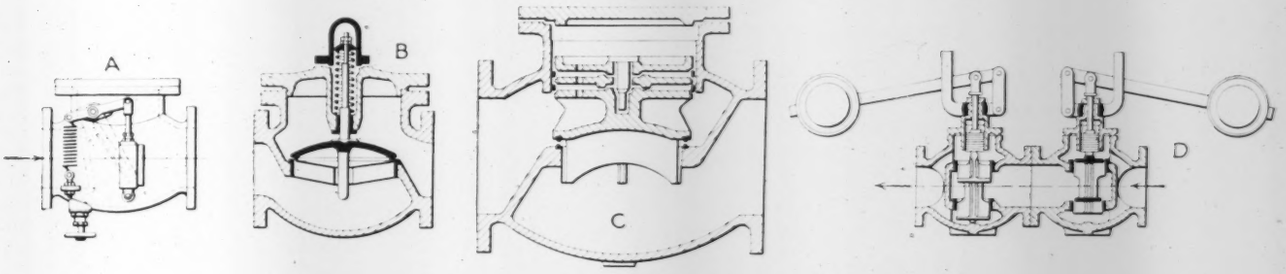


Fig. 6 Pipe-Isolating and Pressure-Reducing Valves

In the first place the steam piping running from the high-pressure boiler to the common pipe must be provided with a pressure-reducing valve by means of which the high pressure of the steam shall be reduced to the lower level and since, as a rule, these pressure-reducing valves cannot be used as stop valves, separate valves of the latter kind have to be installed, in a manner such that they can be safely and easily handled from an accessible place (best from the fireman's side of the boiler). When it is desired to maintain the steam pressure in the high-pressure boilers as uniform as possible and to let into the common piping only the excess of steam, it is advisable to employ mechanically acting devices rather than to rely on the regulation by boiler attendants. This can be done by a so-called overflow valve connected with the pressure reducing valve, one type of which (built by Schaffer and Budenberg) is shown in Fig. D. The overflow valve opens first and lets out the steam as soon as the pressure in the high-pressure boilers has reached a predetermined value, while the pressure reducing valve delivers high-pressure steam to the collector piping as soon as the pressure of the steam in that latter pipe has reached the level of the pressure in the low-pressure boilers supplying steam to the same piping. The article describes also an overflow and pressure reducing valve of Hübner and Mayer in Vienna, said to have given complete satisfaction in actual practice.

Smoke Catchers for Use in Roundhouses (*Uber Rauchfänger für Lokomotivschuppen,* Gwosdz. *Zeits. für Dampfkessel und Maschinenbetrieb,* vol. 37, no. 12, p. 144, March 20, 1914. 3½ pp., 21 figs. *d*). The article describes a number of older types in German practice. In most of these the smokestack valve used to be closed automatically as soon as the smoke catcher funnel was raised, but arrangements might have been made to keep it in any position desired, since the funnel was low down. Further, in these older constructions, an automatic arrangement was provided for placing in the open position the throttling valve when the catch funnel was lowered down. The Prussian railway administration, in 1907, however, found that if the throttling valve on the smoke catcher was fully open there was power-

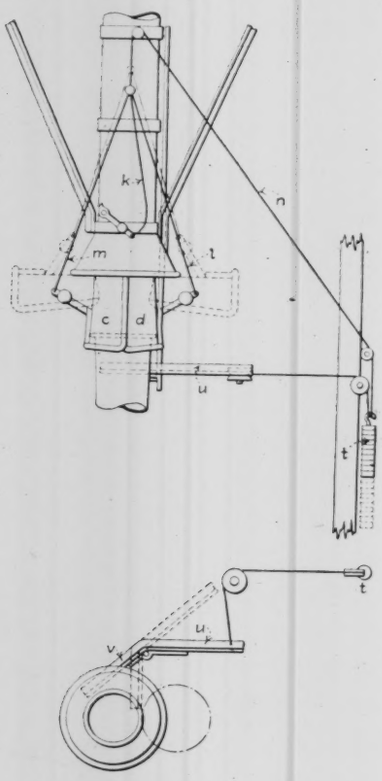


Fig. 7 Fabel Roundhouse Smoke Catcher

ful ventilation over the locomotive, and the latter, especially if it was to go out of service, was cooled down very rapidly. This sometimes produced leaks in the tubes. Therefore an order was issued that no smoke catchers should be used where the throttling valve was automatically opened.

The article accordingly describes a number of apparatus complying with these requirements. The endeavor to make the connection between the locomotive stack and the smoke catcher pipe as close as possible led to the evolution of a special type of smoke catcher, with a divided jointing funnel.

Fig. 7 represents the Fabel apparatus constructed on this principle. The funnel consists of two nearly cylindrical clappets, *c* and *d*, which are movably located by journals and eyes on the smoke pipe and, when inclined, enclose the locomotive smokestack. By means of ropes *l* and *m*, operated by a common wire *n*, they can be placed in the position indicated by dotted lines, and the rope *k* connected with the wire *n* serves to adjust the smoke pipe clappet valve. The latter arrangement has been tested in accordance with the regulations of 1907. The disadvantage of this arrangement lies in the fact that the locomotives must stand almost exactly under the smoke pipe, since otherwise the smokestack would not be tightly enclosed by the clappets. To avoid this and also to make the catcher work with a locomotive having various heights of smokestack, the designer placed between the funnel valve and the smoke pipe an adjustable pipe extension.

Explosions in Water Tube Boilers with Headers (*Explosionen in Wasserrohrkammerkesseln,* Bracht. *Zeits. des Vereines deutscher Ingenieure,* vol. 58, no. 9, p. 344, February 28, 1914. 2pp., *gp.* Paper read before the Lower Rhine Section of the V. d. I.). When watertube boilers were first introduced one of the main arguments in their favor was conceded to be their freedom from explosion danger, and on this account special regulations had been instituted in Germany permitting the use of watertube boilers under conditions where ordinary types of boilers were not allowed. Later, however ,several explosions of watertube boilers occurred which tended to show that this type was not so safe as supposed.

The first explosion of this kind took place in June 1912, in the boiler room of the electrical central station of the Phoenix Rolling Mills at Lerenfeld, Germany. In that plant were four boilers, three of which were made by one concern and the fourth installed in 1910 by another concern. It was this last that exploded. Its rated working pressure was 15 atmospheres, but as the other three boilers were allowed to work with only 13 atmospheres, the same pressure was maintained in the fourth boiler. The heating surface was 412 qm. and the chain grate 14.4 qm. The water headers had a width of 6 m. or 6.080 m. and were made in one piece with arches for the two boiler drums. The width of the frame was 254 mm. and the header 200 mm., the thickness of the header plates being 18 mm. The explosion may be referred back to the fact that a circulation plate in the front part of the header, which was welded in, was entirely torn away, and through the opening that formed, the water content of the boiler rushed out, while the upper part of the boiler broke away from the foundations and pipe connections, broke to pieces and was thrown 50 m. from its original place, causing considerable damage on the way. Bricks and iron pieces flew in all directions for a considerable distance. Two firemen were killed and a third died soon after. One person was seriously injured and six persons less seriously.

The second case of explosion of a watertube boiler took place in November 1912, at the iron works of Menden and Schwerte in Schwerte. Three persons were killed and two seriously wounded. The boiler was installed in 1911 to work at a pressure of 13 atmospheres gage. The heating surface was 300 qm. (3210 sq. ft.), the grate area for hand-firing, 8 qm. (85.6 sq. ft.). The boiler worked in connection with three other boilers of the same size and construction. The explosion was practically a reproduction of the Düsseldorf case. Here also without any previous warning the circulation plate of the header broke off, but remained hanging, since at the corners it had no welds. The opening

which was formed had a cross-section of about 1 qm. (10.7 sq. ft.) through which suddenly water and steam were offered a free passage. The boiler was thrown backwards to a distance of 58 meters (say 185 ft.) in the direction of its longitudinal axis, totally destroying its setting and partly destroying the other boilers, as well as greatly damaging other property.

In November 1912, occurred a third explosion, this time at the plant of the Deutscher Kaiser, at the rolling mill Dinslaken. The boiler had a heating surface of 157 qm. and 12 atmospheres gage pressure and was built in 1897. It has worked since that time with few interruptions, day and night, using the waste heat of two milling furnaces. On the day of the explosion, the boiler which had for some time been out of commission, owing to repairs on the furnaces, was to be again heated up. When the pressure reached approximately 9½ atmospheres, the explosion occurred. The boiler had not yet been connected with the steam piping. Shortly before that a noise had been heard which was falsely supposed to be due to steam escaping from the safety valve. The boiler attendant was thrown some distance and died several hours later. The boiler itself was thrown to a distance of about 6 m. (say 20 ft.). The inspection of the boiler showed that the manhole of the rear header was separated and the staybolts from the circulation plate along the welded seam broken, and that the header was drawn upwards to where it found less resistance offered by the tubes back of the superheater. The nine staybolts in the lowest row have been torn off from the tube wall, while the other seven have been torn out of the manhole wall. In the second row from below there were nine staybolts torn out from the manhole wall. The circulation plate was not deformed. As regards the nine staybolts torn out from the manhole wall, it appears that six of them were broken previous to the explosion while the other three indicated a somewhat more recent fracture.

At first it was supposed that these explosions were caused by defective work, an opinion which was at first endorsed in full by experts and even by the representatives of the manufacturers. The circulation plate was butt-welded toward the header plates and the hammer blows of the welder, which could of course have been applied only from the outside of the connection, probably caused the weld to take place in such a manner that the plate edges were superimposed. The connection between the metal elements was so slight that traces of old chiseling could easily be seen on the circulation plate. On the inside of the header the iron shavings which were used as a welding material have melted and flown into one piece with the walls so that there was available both a tight connection and a certain amount of strength. Test pieces have been cut from the plates and investigated and it was found that the walls were made of wrought iron, having strength of 34 to 41 kg/qmm. which could be easily welded. On the lateral circulation plate of the latter, the test pieces show a materially better weld than was the case on the bottom plate. These circumstances confirmed the assumption that in the manufacture of the bottom seam the art of welding may have been imperfectly applied and that for some reason the workmanship was at fault.

The manufacturer, however, would not accept this view, since the welder who worked on this header was an old worker, in the business for many years and has made many headers without any trouble. Therefore he insisted that the cause of the explosion be sought in some irregularity of operation, such as, for example, the possibility of the chamber (owing to a break in the arch) being exposed to the fire for a comparatively long time. In addition, there was considerable mud and boiler scale pieces collected in the lower part of the header which might have led to overheating of the seam and to a rupture of the parts. This assertion of the manufacturer was thoroughly investigated and may be considered as having some foundation in a certain sense. During the night before the explosion 30 to 40 bricks fell from the lower arch ring of the grate. This circumstance alone could not have caused over-heating. A case is on record where one-half of the fire arch broke down. In that case, however, part of the arch which broke was near the hopper, and for operative reasons the work of the boiler had to be continued for a certain time, this being done by closing the wall by a fire sheet so as to prevent a false entrance of air. In both cases, fault of attendance can therefore be left out of consideration, although it must be admitted that an overheating of the plates had taken place, as shown by blue spots in one place on the plate.

It is hardly possible to admit that the presence of mud and boiler scale inside the boiler intensified over-heating, since, water of condensation with 5 per cent supplementary water, which passed previously over a cleaner, was used as feedwater. In addition, owing to the inclined position of the header, in the lower part of the latter there was a sort of dead angle in which all the impurities present used to deposit. The speaker was therefore of the opinion that in this case also the cause of the explosion lay not in the defective workmanship of the seam but in a defective method of setting of the boiler which had not sufficiently protected the seam from overheating. In the Schwerte explosion it was found that the circulation plate and the lower part of the header wall showed blue spots, while inside the walls was found a scale deposit of 5 to 8 mm. (0.2 to 0.32 in.) thick, while the mud contained a considerable amount of oil. It appears further, that the overheating of that particular spot was also intensified by the fact that the protective setting of the header was partly broken and crumbled up. Here also, therefore, the setting had not afforded sufficient protection to the seam and the overheating finally caused its failure.

The third case in Dinslaken is materially different. Overheating did not seem to have played any material part in the accident which appears to have been brought about mainly by the failure of the staybolts, which were placed too far away from the edge (200 mm. or 8 in.) so that the seam was stressed too high.

The author discussed further the lessons which can be drawn from these explosions and the preventive measures which should be taken to avoid their repetition. The Central Association of Prussian Societies for the Inspection of Boilers has decided to carry out a series of experiments by building a number of test headers in order to test thoroughly the distribution of strength, not only in headers which have been produced by butt-welding, but also of those which have been produced by other methods without welding. These tests have not yet been completed. The author had occasion to be present at tests when all boilers had been broken by water pressures, butt-welds had broken at pressures from 50 to 60 atmospheres, the butt-welds here used being of the

same type as in the exploded boilers. This would indicate that the butt-weld, although not an ideal method of making a seam, was still strong enough to bear all regular strains. But in the operation, suitable conditions must be maintained, and if this were done, the faith in the reliability of the double header boiler might be recovered. In Germany there are now 15,000 to 20,000 of such boilers at work and giving good satisfaction, and the few cases of explosions, though certainly regrettable, ought not to prejudice against this type of boilers.

Strength of Materials and Materials of Construction

TESTING FIRE BRICKS (*Die Prüfung feuerfester Steine*, A. Gary. *Feuerungstechnik*, vol. 2, nos. 11 and 12, pp. 178 and 199, March 1 and 15, 1914. 9 pp., 14 figs. *dp*). Prof. A. Gary, head of the great experimental station at Gross Lichterfelde West, presents in the present article a description of methods used for testing fire bricks, covering the following subjects: Chemical composition of the brick, determination of its shape, consistency, space, weight, specific weight and density, volume after repeated heating, compression and expansion, variation of length with heating, heat conductivity, melting temperature as compared with that of Seger cones, softening and change of consistency in heating and in contact with other bodies, compression strength when cold or hot, and porosity with respect to gases. The author discusses in detail the methods used and suitable apparatus for determining all these factors.

HEAT CONDUCTIVITY, SPECIFIC WEIGHT AND POROSITY OF REFRACTORY MATERIALS (*Wärmeleitfähigkeit, spezifisches Gewicht und Porosität feuerfester Steine*, P. Goerens. Cp. *Feuerungstechnik*, vol. 2, no. 12, p. 204, March 15, 1914. *e*). Paper presented by Prof. P. Goerens at the 34th meeting of the German Association of Manufacturers of Refractory Materials. In establishing a heat balance of metallurgical processes, under the heading "heat losses through conduction and radiation" are given values which evidently require to be corrected. This is due to lack of proper methods for determining these losses and to their determination as the difference between computed input and output of heat, so that, for example, in some of the blast-furnace heat balances the heat losses over radiation and conduction varies from 0.58 to 33.3 per cent of the total heat. These wide variations are in the first place due to the fact that practically all the errors in other observations are lumped up under the heading "heat losses through conduction and radiation."

Engineer J. W. Gilles has performed a series of experiments in the Metallurgical Institute of the Aix la Chappelle Technical High School, using bricks of normal type in order to determine directly the heat conductivity of fire brick. The apparatus consists of an electrically heated plate, by means of which the surface of the brick was heated, a calorimeter for the determination of the heat coming through, and a number of thermoelements for the determination of the distribution of temperature in the mass of the brick. In addition to the heat conductivity of the brick there were also determined its true specific weight g_w, apparent specific weight g_s and the absolute porosity P_{abs} determined from the formula

$$P_{abs} = \frac{g_w - g_s}{g_w} \times 100$$

From these data it appears that the absolute conductivity increases with the temperature in the case of fire brick, half fire brick, slate, lias, silica and carbon, but noticeably decreased in magnesite. Further, in chemically similar refractory substances, the heat conductivity decreases with porosity.

ENGINEERING SOCIETIES

AMERICAN RAILWAY ENGINEERING ASSOCIATION

Bulletin, vol. 15, no. 163, January 1914, Chicago, Ill.

Report of Committee on Iron and Steel Structures
Report of Committee on Masonry
Report of Committee on Wood Preservation (Abstracted)
Report of Committee on Grading of Lumber

REPORT OF COMMITTEE ON WOOD PRESERVATION (54 pp., 28 figs. *eA*). The report on wood preservation discusses the use of oil from water gas and coal tar in creosote oil, and comes to the conclusion that wherever possible only grade 1 coal tar creosote should be used and under no circumstances should coal tar be added to creosote of this grade. Where it is advisable to use coal tar in mixture with the lower grades of creosote, such as grades 2 and 3 of the American Railway Engineering Association and poorer, the following precautions should be adhered to: There must be a distinct understanding between all concerned that a mixture as specified is used; the coal tar should be added to the creosote only at the plant and under the direct supervision of the railway company; under no circumstances should the coal tar constitute more than 20 per cent of the mixture. The coal tar and creosote should be thoroughly mixed at a temperature of approximately 180 deg. fahr. before being applied to the timber, the tanks containing the mixture being heated and agitated thoroughly before any oil is transferred to the working tanks. Only low carbon coal tar can be used. The amount of free carbon should not exceed 5 per cent, and in treating with the mixture, the temperature of the solution in the cylinder should be not less than 180 deg. fahr.

The article quotes records from service tests with periodical inspection of the sections of test tracks of various railroads as well as the methods of determination and valuation of various values under test. In an appendix is given an extensive discussion by Hermann von Schrenk and Alfred L. Kammerer on the use of refined coal tar in the creosoting industry in which the authors object to the view of considering coal tar additions as adulterations, and by a series of experiments come to practically the same conclusions as stated above, insisting upon the necessity of stopping the practice of selling creosote oil mixed with coal tar as No. 1 grade oil.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Journal, vol. 26, no. 1, February 1914, Washington, D. C.

A METHOD OF CLOSING PORES ON HOLLOW BRASSES, Capt. F. W. Bartlett, U.S.N. (4 pp. *p*). On the U.S.S. Montana it was found that the six bottom brasses for the main shaft of each engine were porous, so that water from the water service mingled with the oil of the journals to a slight extent. The babbitt metal of the brasses, however, was in excellent condition and the leaks were not where the babbitt was located, but at other points of the brasses and at points where the babbitt was cut away. As it was a very expen-

sive proposition to fit new brasses, the following method for making tight the old ones was attempted and found successful.

Method Used. The brasses were first filled with gasolene and subjected to a pressure of about 20 lb. and left in this condition for about 12 hours. It was found that the gasolene worked its way through the crevices and appeared at the small openings, and in some cases carried with it what appeared to be particles of red lead, giving the impression that an attempt had been made at some time to close these crevices by forcing in red lead under pressure; but this could not be proved. The idea of using the gasolene was thoroughly to clease the crevices of oil and water. The gasolene was then removed and air blown through for four hours and the brasses were then filled with shellac and a pressure of 75 lb. of compressed air was put on this shellac and it was kept in this condition for about four hours, the idea being that the shellac would not settle materially in that time. It was found that the alcohol appeared to push ahead of it small particles of water or gasolene, and appeared as drops at the small crevices, and in some cases the shellac could be seen clearly to have passed through these crevices and to have arrived on the outside as a brown liquid. This, however, soon congealed and no further leaks took place. The shellac was then removed and compressed air blown through the brasses for three or four hours with the idea of setting the shellac on the surfaces within, although it was realized that the shellac in the small crevices would be in no way affected. After this the brasses were filled with water and tested to a pressure of 75 lb., with no sign of leakage after an hour of observation.

Shellac was the material which seemed best adapted for this purpose over all others considered, but it is believed that some other material might be found to accomplish this purpose, and a material which would not become soft at as low a temperature as shellac. Experiments along that line should be conducted.

INSTITUTION OF ELECTRICAL ENGINEERS

Journal, vol. 52, no. 231, April 1, 1914, London

STEAM BOILER WORKING IN ELECTRICAL POWER STATIONS, J. W. Jackson (7 pp., 4 figs. *g*). The author points out that the watertube boiler has been adopted almost universally on account of the ease with which it deals with fluctuations in the load. He advocates the straight-tube vertical boiler, but remarks that the designing of these boilers is by no means a simple matter, some difficulty being experienced in arranging the drums to accommodate the extra number of tubes without, at the same time having to press the drum ends or sides into bad shapes.

Modern competition appears to have called for a superheater of a smaller area, but placed in a much hotter portion of the boiler. In dealing with this question the author shows a strong preference for the arrangement illustrated in Fig. 8A. These superheaters, designed ten years ago with ample surface, were fixed in the boiler at a distance much further from the furnace, with the result that they are much steadier to work and of almost everlasting wear. They also have the advantage that the amount of superheat can be reduced without overheating the tubes. The author assumes that the fixing of the comparatively small superheater (Fig. B) in such a hot position of the boiler is due to first cost, but he considers the difficulties in operation are increased as regards maintenance, reliability and control. He also thinks that, as really high superheated steam is coming into use and steam temperatures of from 700 deg. fahr. to possibly 900 deg. fahr, at the turbine stop valves are likely to be required before very long, troubles will increase somewhat alarmingly if the superheater of the future is fitted in such a hot position of the boiler.

The author discusses many other details of modern boiler practice, as the design of boiler furnaces, Co_2 indicators, firebricks, stokers, pneumatic and hydraulic ash-handling systems, feedwater treatment, etc.

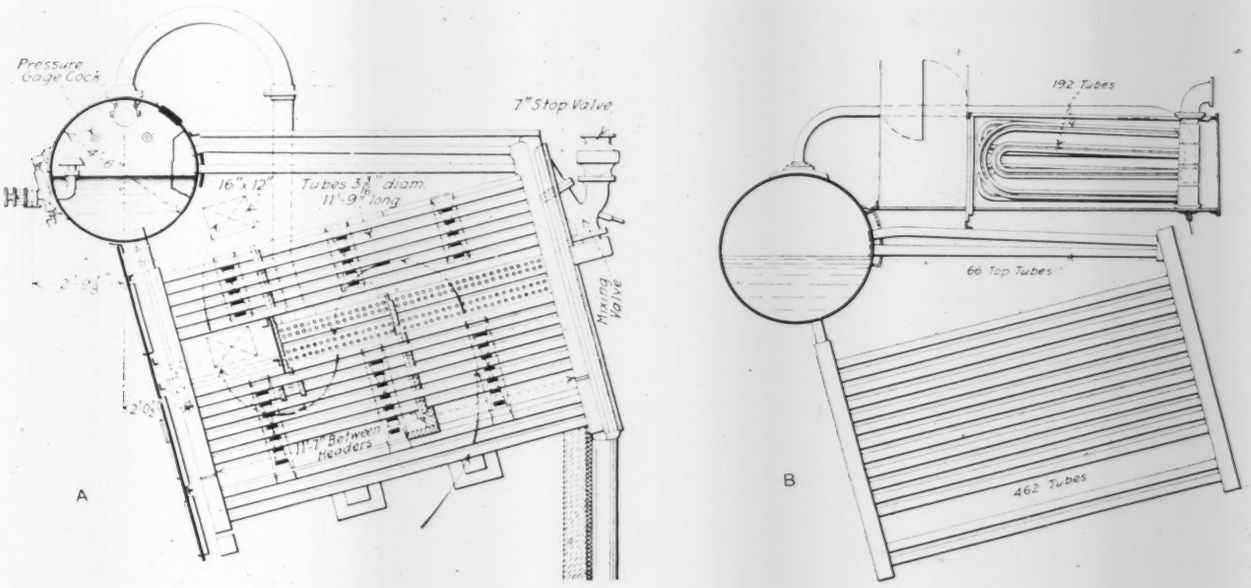


FIG. 8 SUPERHEATER LOCATION IN A MODERN BOILER PLANT

MANCHESTER ASSOCIATION OF ENGINEERS

SUN-POWER PLANT, Frank Shuman. At a meeting of the Manchester Association of Engineers in Manchester, March 14, 1914, Frank Shuman read a paper on the Sun-Power Plant. As the Proceedings of this association are not yet available, this abstract is made from an account in Engineering, March 27, 1914. The cost of producing power from sun rays appears to be such that sun-power plants for the present need not compete with plants using coal at any tropical place where coal is reasonably cheap. Work had to be confined to places where the sun was at its best and where coal cost from £3 to £8 a ton. The speaker then described in detail the engine which he constructed for the pumping plant at Meadi, near Cairo, Egypt. The steam is generated in five sun heated absorbers arranged in a manner such that they are always facing the sun throughout its course during the entire day. The calculations given by the speaker show that with coal at £3 per ton there was in the Meadi plant a saving of £410 per annum, with the extra first cost of £790 of the sun-power plant over that of the coal consuming plant, so that in less than two years the saving in fuel would cover this extra cost.

NEW YORK RAILROAD CLUB

Advance Paper presented at April 17, 1914, Meeting, New York

THE ART OF LOCOMOTIVE STAYBOLTS, C. A. Seley (6 pp., 2 figs. *dp*). The locomotive boiler is a structure which is severely taxed, as a result of which there are numerous cases of staybolt breaks. Under the Interstate Commerce Commission Code of Rules no boiler shall be allowed to remain in service where there are two adjacent staybolts broken or plugged in any part of the firebox or combustion chamber, nor when three or more are broken or plugged in a circle four feet in diameter, nor when five or more are broken or plugged in the entire boiler. The cost of repairing a broken staybolt is not simply that of the labor and material employed, but also some portion of the value of the service of the engine, from $25 to $100 per day, which is lost thereby, and this makes it very important to have the staybolts stay up as long as possible. With a well-designed and built boiler equipped with solid staybolts, there should not be any serious trouble until about the third year of its use. Length of staybolts has much to do with their relative rigidity. There appear to be what may be called "breaking zones," which, generally speaking, include the end and top rows of side sheets, outside rows on back heads, most of the throat sheet bolts, and in large boilers all the stays of combustion chambers to the shell sheet except the radials. The radial stays securing the crown sheet are generally long enough to have the necessary flexibility which prevents their breakage except those which stay the upper corners of the firebox. These corners are arches, very stiff and rigid as compared with other parts of the box, and as the stays are not truly radial to the outer sheet, the staybolt holes are tapped at an angle with more or less of incomplete threads. Experiments have been made showing that the relative expansions of the firebox and outer boiler sheets, when under pressure, are not alike and their staybolts, in addition to the tensile load imposed by the pressure, have also an angular strain due to these irregularities. It is these angular movements many times repeated that account for broken staybolts after the direct cause is taken care of by the relatively high factor of safety. It appears that staybolts do not break on account of lack of strength of the cross section, but on account of the overstressing of the outer fiber due to angular vibration. Rapid and uneven heating of the firebox in firing up, as well as in cooling down and washing, produces the greatest amount of angularity and accounts for the unusual checks, although at these times there is no pull on the bolts. The location of the fractures is significant. As a rule a solid staybolt breaks close to the outer sheet, apparently because it is heavier than the fire sheet, is stiffer, does not respond by buckling, and therefore acts in a way as a foundation. The speaker asks whether the rigidity of the sheets does not cause them to act as levers in the staybolt holes of the firebox sheets, and on the material around the holes, stressing it to the point of failure and accounting for the cracking of sheets, which must have a starting place, and that at the bolts and not between them. The remedy for this would be more flexibility on the body of the bolt between the sheets to reduce the stress on the outer fiber and also reduce their strength as levers to punish the firebox material, reduce the buckling and save the fireboxes. One of the more recent developments in the art aims directly to increase the flexibility of the body of the staybolt to eliminate breakage and also save the firebox sheets by the simple expedient of making staybolts with a body of two pieces of half-round iron, thus having two neutral axes each much closer to the outer fiber than in the solid section, and then by twisting the body present the plane of greatest flexibility in each direction in which the latter turns. The comparison of such a structure with that of the solid bolt is shown in Fig. 9.

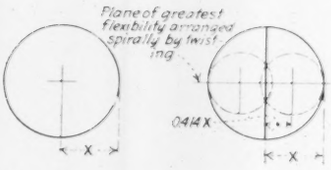


FIG. 9 TWO-PIECE AND SOLID STAYBOLTS COMPARED

SOCIETY OF AUTOMOBILE ENGINEERS

Vol. 5, no. 6, March 1914, New York

INFLUENCES AFFECTING THE FUNDAMENTAL DEFLECTIONS OF LEAF SPRINGS, D. Landan (36 pp., 15 figs. *etA*). There appear to be a very large number of variables that affect the flexibility of springs, making this branch of engineering a highly specialized work. The formulae often called for the deflections of a leaf spring are all based on the theory that the spring is a beam encastré at one end and loaded at the other end, or that it is a beam supported at its ends and loaded in the middle. There is no room to doubt that the partial lengths of a spring are to be regarded as cantilevers with loads at their free ends. All efforts, however, to obtain an equation which would cover this piece of apparatus have been unsuccessful. One of the faults lies in the assumption that in a spring, the leaves of which are of the same thickness and decrease in length by equal steps,

the leaves are under a uniform stress and on that account the spring bends to the arc of a circle.

The author strongly objects to the assumption that the modulus of elasticity varies in spring steel. Heat treatment, no matter how varied, has no influence on this coefficient, as the author proves by numerous data of tests, showing that methods of preparation, heat treatment and chemical composition seem to have no practical influence on the property of stiffness. Carbonization and hardening of the surface are also without effect on the value of the modulus of elasticity. Further, the investigations of Henry W. Bearce have shown that there is a slight increase in the modulus at the elastic limit and that Hooke's law holds at the elastic limit, neither does the modulus appear to vary with time and rest, as shown by investigations made in connection with chronometer balance springs. From the investigations of William Dalby, the author concludes that, so far as this kind of spring steel is concerned, tempering the steel has very little influence on the value of the modulus of elasticity.

The apparent difference of stiffness in various cases may often be accounted for by other considerations: First, two plates of spring steel of the same nominal dimensions, and of different or the same chemical constitution, coming from two different rolling mills, will usually be found to be of different thicknesses, sometimes with a variation as great as 0.005 in., which is enough to account for the observed difference in flexibility. Springs pass through a number of operations before they are ready for assembling. They have to be trimmed, milled, fitted and heat-treated; for every one of these operations the plate has to go into the furnace and every insertion into or removal from the source of heat produces a certain amount of oxide or scale which decreases the working thickness of the plate, with the result that the plate will be thinner than the normal thickness by an amount depending on the number of heats that it has to undergo. The author describes the basis of providing for this thinning of the leaves. The grinding of both sides of the leaves of high-grade touring car springs is gradually being discontinued, because it is not improbable that two different workmen with different grindstones may turn out leaves which only appear to be identical, and the finished springs will show a marked difference in flexibility.

The friction of plate springs plays an important role in the operation of a spring. A spring freshly lubricated will execute its oscillation more freely than one that has been allowed to rust and run dry. A case is recorded of a spring loaded to its correct height for several months taking an apparent set of nearly an inch on releasing the load. The investigations show that the "set" was due to rusting, and the spring was restored to its initial height by putting oil between the leaves and causing it to oscillate. The author quotes Professor Dalby's investigation on internal friction, but disagrees with him on some particulars.

As regards shackles, there is very little published information. The two considerations with which the spring engineer is concerned are the effect of tight shackles on the freedom of action of the spring and the effect of the obliquity of the shackles on general shape of the springs to which they are attached. The author discusses both of these points in full. The effect of placing a shrunken band on a leaf spring is to increase its stiffness. Some investigators have considered the full length of the band to be effective in clamping the springs, but experiments conducted under the author's direction indicated that this assumption is incorrect, and it appears that only about 0.4 of the length of the band is efficient (complete data on these banding tests are given in the article).

WESTERN SOCIETY OF ENGINEERS

Journal, vol. 19, no. 3, March 1914, Chicago, Ill.

THE CEMENT GUN AND ITS WORK, Carl Weber (35 pp., 24 figs. *dp*). The product of the cement gun is called "gunite" in order to distinguish it from ordinary cement stucco or plaster work, and for the reason that the material develops qualities which put it in a class by itself. Gunite is usually a cement mortar composed of about one part of portland cement and three parts of coarse, sharp sand passing through a $\frac{3}{8}$-in. screen.

The material leaves the nozzle with a velocity of about

RESULTS OF COMPARATIVE TESTS

Made to compare the properties of handmade stucco with gunite. This table is computed from independent investigations made by Westinghouse Church, Kerr & Co. Engineers, N.Y. Given in detail in their report of Nov. 1911

MIXTURE 1 TO 3

Dykerhoff Portland Cement and Cow Bay Sand passing $\frac{1}{8}$ inch screen

TEST MADE FOR	RESULTS HAND	RESULTS GUN	RATIO DIAGRAM (Handwork / Gunite)	RATIO
TENSION lb. per sq. in.	254	441	0 — 254 — 441	1.74
COMPRESSION 1-lb. per sq. in.	2084	3530	0 — 2084 — 3530	1.70
VOIDS Percentage	19.2	12.7	0 — 12.7 — 19.2	0.66
PERMEABILITY Com. per hr. on 0.02 °m.	3.0	0.44	0 — 0.44 — 3.0	0.15
ABSORBTION Per Cent by Weight	5.1	3.67	0 — 3.67 — 5.1	1.40
ADHESION On brick lb. per sq. in.	272	386	0 — 272 — 386	1.42

FIG. 10 HANDMADE STUCCO AND GUNITE; RESULTS OF COMPARATIVE TESTS

300 ft. per sec. and as it strikes the hard surface the sand will rebound and fall down. Only the neat cement will first adhere until a coat thick enough to hold the sand has been formed. Then the rebound stops almost entirely and the coat is built up grain by grain until the required thickness has been obtained. In this manner a film of neat cement is automatically formed between the old and the new work on every inch being covered, thus sealing every pore.

As the "shooting" continues the forcing ahead of the neat cement by impact is continuously repeated, and every grain of sand which does not find a perfect bed or which is not immediately enveloped with cement will rebound and be forced out. Any pores remaining will be immediately filled by the following mass and all air and surplus moisture is forcibly ejected.

Field and laboratory tests were made by Messrs. Westinghouse, Church, Kerr & Company, of New York, to compare the qualities of handwork with gunite. The final report which very elaboately shows in figures, words and photographs, all the different testing machines and methods employed, gives the results of these tests as follows:

"In all of the tests made the product of the cement gun showed superior to good handmade products of the same kind. The degree of superiority varied between wide limits.

In tensile strength the gun work excelled hand work in every case by amounts ranging from 20 to 260 per cent.

In compressive strength the excellence of the gun work was even more marked, ranging from 20 to 720 per cent better than hand work.

In the matter of surface permeability the gun work absorbed from 710 down to 120 as much water per hour, per unit of area as the similar handmade surfaces.

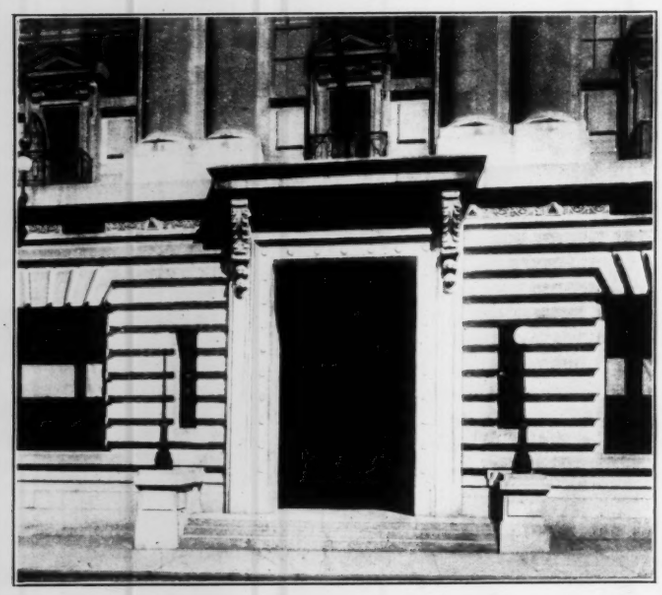
As regards absorption of water, the handmade mortars took up from 1.4 to 5.3 times as much as the gun-made mortars.

The percentage of voids of the gun-made product ranged from 52 to 75 per cent to that of the handmade mortar.

The adhesion of the gun-applied mortars was on an average 27 per cent better than that of the hand work."

In order to show, in condensed form, the comparative values of results of these tests, the author gives a ratio diagram for the one-to-three mixture as shown in Fig. 10.

Although these tests greatly favored the handwork, they prove conclusively the superiority of gunite. The cement gun gives a perfect bond and forms a coating of a density which it is impossible to produce by any other known method.



Main Entrance to the Engineering Societies Building, New York. This entrance opens upon the large foyer which occupies the whole of the first floor and is a congregating place at times of conventions. Ordinarily one enters by doors at the left of the main entrance, which lead directly to the elevators. At the time of meetings, however, the center doors are swung open to visitors. Every engineer, the world over, is welcome here.

FOREIGN REVIEW AND REVIEW OF THE PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

An interesting example of what Sir Henry Bessemer called "cross-fertilization of sciences" is presented in this issue of the Engineering Survey: The formula for wind pressure on roofs is to be revised on the basis of data obtained in aeronautics.

THIS MONTH'S ARTICLES

Slessaryoff investigates the coefficient for the friction of a stream of gas discharging against the adjoining layers of air. In another article the efficiency and economy of jet apparatus, as compared with electrically driven pumps, for handling the circulation of water in a large heating plant is compared, the results being on the whole in favor of the jet apparatus. In the Machine Shop section is described an interesting device for keeping nuts on bolts, as well as a device for restoring the cylindrical shapes to deformed pieces.

Data on comparative tests of various materials used for impregnating mine timbers are also quoted. In the section on Mechanics will be found information on the use of jet apparatus as mixing machines, and on the conditions of self-rotation of plates immersed in a liquid, showing that in such a case the self-rotation depends on the moment of inertia of the system. Further, a new furnace for heat treatment of railway car-wheel tires is described.

In the section, Steam Engineering, will be found a statement concerning a process of determination of efficiency of blast-furnace boilers exclusively by means of analysis and temperature measurements of the heating gases and flue gases. The steam consumption of a rolling mill straight-flow steam engine is investigated, and its high economy shown. Ofterdinger describes his new system of feedwater preheating, designed particularly for use on steamers: water is preheated in two stages: in the first by exhaust steam from the auxiliary engines and low pressure receiver, and in the second by steam from the intermediate pressure receiver (triple or quadruple expansion engines). O. Dobbelstein, from data furnished by extensive tests made in Germany, discusses the application of surface combustion to boiler heating, and the improvements, partly made, partly projected, in this process in Germany. In addition to the use of gas, he speaks also of surface combustion firing with tar-oil as a fuel, and concludes that as yet it cannot be relied upon for continuous operation.

The problem of fuel saving through proper dimensioning of steam piping is discussed in the next abstract, and it is shown that the formulae used at present for the determination of pressure fall in various pipes and connections are utterly unreliable, and are apt to give too low results.

Mr. Freyn, in a paper before the American Institute of Mining Engineers, discussed the utilization of coke-oven and blast-furnace gas for power purposes, as well as a mixture of the two gases. The question of the use of reinforced concrete for docks, mainly with regard to the European practice, is the subject of the paper of Harrison S. Taft before the American Society of Civil Engineers, before which was also presented the paper of Guy B. Waite on Cinder Concrete Floors. J. L. Van Ornum, in a paper before the Association of Engineering Societies, establishes the effect of saturation on the strength of concrete, the rapid loss of strength on the first exposure and the slow and gradual recovery. Cast-Iron Wheel Records and Cleavage and Crystallization of Cast Iron are subjects of papers presented before the Canadian Railway Club.

The various articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

FOREIGN REVIEW

Air Engineering

CONCERNING THE WIND PRESSURE ON ROOFS (*A propos de la pression du vent sur les toitures*, A. Sée. *Revue industrielle*, vol. 45, no. 2131-14, 1914, p. 186, April 4, 1914. 1 p., 2 figs. *pt*. From paper read before the Industrial Society of Northern France). Recent experiments in connection with aeronautics have raised a good deal of doubt as to the validity of the officially adopted formula for wind pressure against roofs and walls. It is usually assumed that the wind pressure on a surface with the plain normal to the direction of the wind is equal to the product of the area of the surface by the square of velocity times the coefficient 0.14. In the case of a roof it is assumed that the wind moves downwards at an angle of 10 deg. and strikes the roof at an angle $a + 10$ deg., where a is the angle of the roof with the horizon. Under these conditions the pressure is obtained by multiplying the preceding equation by $\sin^2 (a + 10)$. This official formula is, however, entirely antiquated and its lack of accuracy is obvious now that the coefficient of resistance of the air is known to be not 0.14, but 0.08. The hypothesis of the wind descending at an angle of 10 deg. is purely arbitrary. The law of sine square has been shown not to agree with experimental data, and finally the formula does not take into consideration the shape and location of the roof.

Experiments have been made recently at the Engineering Aeronautical Battalion of the Italian Army with models of two types of semi-lozenge shaped hangars (Fig. 1 A and B), where the pressure curve and the magnitudes of the pressures, at various points of the profile, are indicated. One sees at once that the pressure curve has nothing to do with either the sine square or simple sine law, or indeed with any law based on the angle of incidence. The wind pressures along the frontal surface of the structure rapidly diminish as the curve inflects, and become zero some time before the tip of the lozenge is reached; moreover, they become negative all along the rear surface, a fact which is not shown by the formula: There is therefore quite an important partial vacuum, independent of the curvature of the structure, and it appears that the wind pressure on each element depends not so much on the angle of incidence at that point as on

the location of that particular element with respect to the rest of the structure.

When, however, one comes to the consideration of the question as to which formula would be more acceptable than the old official formula, one finds that while this official formula is incorrect, any other formula which might be derived at the present time would be just as likely to be based on arbitrary assumptions and involve coefficients of doubtful value. Whether the new formula would give better results is somewhat doubtful, while it is a fact that structures built in accordance with the old formula proved to be quite stable. The author, therefore, rather curiously arrives at the conclusion that while the old formula is admittedly incorrect it should still be followed, at least until an absolutely good new formula can be derived.

INVESTIGATION OF THE DISTANCE OF FLOW OF A FOUNTAIN OF HOT AIR (*Izsledavaniye dalnaboynosti fontana teplava vozdookha,* V. Slessaryoff. *Journal of the Russian Metallurgical Society* (in Russian), no. 6, 1913, p. 709. 5 pp., 3 figs. *e*). In investigating analytically the problem of gas fountains one has to deal with a certain coefficient which takes care of the friction of the stream of gas against the

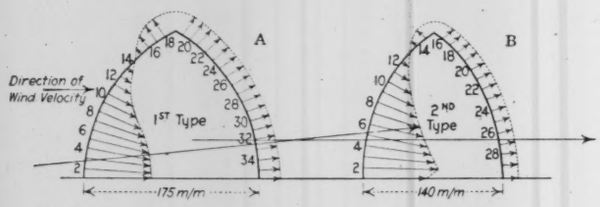


FIG. 1 DISTRIBUTION OF WIND STRESSES ON BUILDINGS

adjoining layers of air. Practically no experiments have been made to determine it. The author investigated the action of a stream of air in a special apparatus described below and manipulated the results obtained in such manner as to determine the coefficient K in the equation of I. G. Yesman:

$$H = \frac{v^2}{2g} \cdot \frac{273 + t_n}{t_d - t_n} K$$

where H is the distance of flow of the fountain in meters, v initial velocity in meters, t_d temperature of the moving stream, t_n temperature of the surrounding stationary medium and K a coefficient.

In Fig. 2 A (outflow nozzle) H is height of flow of the fountain of warm air, H_o, height of flow of the fountain of unheated air. Normally to the direction of the stream is laid off the speed of the flow of air v; the solid curve represents the law of variation of velocity as a function of the distance of the heated stream having an initial temperature t_d; the dotted curve represents the law of variation of velocity of the unheated stream. The figure shows that the distance of flow of the heated stream is less than that of the unheated steam. If the magnitudes of the velocity and temperature be substituted in the equations, we shall obtain H larger than that obtained experimentally. We must therefore introduce into the equation a coefficient K which would satisfy the equation. The author found that the value of this coefficient is $K = 0.7$.

The experimental apparatus is shown in Fig. B. On a special support is placed a small electric motor, carrying on its shaft the drum of a small Sirocco blower with the outflow nozzle directed in such a way that the stream of air goes vertically downwards. The blower can deliver up to a velocity of 16 meters per second, this velocity being regulated within wide limits by means of a double rheostat placed on top of the supports. The air enters the blower through a bend with a little dome under which has been placed a kerosene lamp for heating the air; this lamp can be raised and lowered as desired by means of a movable support and screw. Two valves are placed in the tube for regulating the temperature of the air, one taking care of the warm air and the other of the cold air; by lowering the lamp and by manipulating the valves one could obtain practically any desired temperature for any given velocity of the outflow of air. At the beginning of the stream, the temperature would be measured by means of an ordinary thermometer located on the support, but the temperatures in the other parts of the stream have to be measured by a special thermometer which would be sensitive to rapid variations of the temperature of the air. Such a thermometer was made by the author in the shape of a conical vessel with walls of very thin copper (0.03 mm. or 0.001 in. thick), the inside of the cone being con-

TABLE 1 DISTANCE OF FLOW OF A FOUNTAIN OF HOT AIR

t_d Deg. Cent./Fahr.	H Meters Actual	H_1 Meters Calculated	$K = \frac{H}{H_1}$
60/140	1.08	1.58	0.683
75/167	0.835	1.18	0.707
85/185	0.745	1.015	0.730
			$K_{average} = 0.707$

$t_n = 15.5$ and $v_{max} = 2.2$

nected by a thin rubber pipe with an alcohol manometer. The air becomes heated in the vessel, expands and displaces the alcohol in the glass tube of the manometer; after the instruments have been properly calibrated, one can read the temperature from the manometer scale. In order to avoid the disturbing influence of barometric pressure, the internal space of the reservoir is placed from time to time into communication with the external air. Copper was selected as the material for this vessel owing to its high heat conductivity. The velocity of the flow of air was measured by an ordinary wing anemometer. The experiment was carried on in a large room with a temperature of the surrounding air of 15.5 deg. cent. (59.9 deg. fahr.), the room being so large that the blast of warm air practically did not affect the room temperature. The results of the investigation are presented in Table 1.

In the first column is given the initial temperature of the gas fountain, in the second the distance of flow of stream H, then H_1, the distance of flow of stream calculated from the Yesman equation (with coefficient unity), and in the last column values for the coefficient K. The initial velocity was all the time maintained constant and equal to 2.2 meters (7.2 ft.). The distance of flow of the stream of the fountain can be determined very exactly by means of the air thermometer described: even after the anemometer has stopped entirely, the thermometer would still indicate a flow of warm air. The coefficient K appears to vary somewhat with the initial tem-

perature, but for practical purposes its value may be accepted as 0.7.

Heating

THE WATER CIRCULATION SYSTEM IN THE HOT WATER CENTRAL HEATING PLANT OF THE COUNTY HOSPITAL AT KREMSIER (*Uber den Wasserumtrieb des Warmwasser-Fernheizwerkes der Landesheil- und Pflegeanstalt in Kremsier (Mähren)*, F. Heinl. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 17, p. 658, April 25, 1914. 3 pp., 5 figs. *de*). The article describes the hot water central heating plant at the County Hospital in Kremsier, the interest of which lies in the fact that at first pumps were used for driving the hot water, but in 1912 they were replaced by a jet apparatus.

The boiler plant consists of one low-pressure hot water

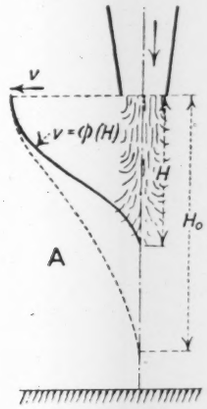


FIG. 2, A AND B FLOW OF A FOUNTAIN OF HOT AIR AND APPARATUS FOR MEASURING IT

boiler of 75 qm. (807 sq. ft.) heating surface and two high-pressure steam boilers of 140 qm. (1506 sq. ft.) heating surface, each working at a pressure of eight atmospheres absolute. Originally three centrifugal pumps, working either singularly or in parallel, were used to drive water through the hot water boiler into the direct piping. These pumps were driven by direct-current motors at 440 volts and 675 r.p.m. In the installation of the jet apparatus, the following points had to be considered: (*a*) the rise of temperature t-t_1 in the steam jet apparatus can be determined approximately from the equation $t\text{-}t_1 = a\sqrt{h}$, where h is the delivery head in meters of water (difference of pressure between the direct and return flow) and a is a constant which has a value of 4 to 5.5 when the amount of water is right; (*b*) when, with a delivery head remaining constant, the amount of water is decreased, the amount of steam used remains nearly equal, and is therefore approximately inversely proportional to the amount of water; (*c*) the amount of water ought not to fall below one-half to one-third of the maximum value. In the present case three jet apparatus have been installed having a diameter of 120 mm. (4.8 in.) for the water end and 80 mm. (3.2 in.) for the steam end, arranged in a manner such that they may be used either singularly or in parallel. Water in the jet apparatus is heated approximately 10 to 12 deg. cent. (18 to 21.6 deg. fahr.); for the measurement of the amount of water delivered a venturi nozzle, M (see Fig. A), is used.

Data of the tests of the plant with pumps are given in Table 2; temperature of water in the pumps during the tests was on the average of 64 deg. cent. (147.2 deg. fahr.) and in passing the hot water boiler was raised to 77 deg. cent. (170.6 deg. fahr.). The pumps were inserted first singularly, then in pairs and finally all three together in parallel. The readings were taken for the amount of water Q in cu. ft. per hr., pressure difference in front of the pump and behind the hot water boilers, and current i, the voltage being always 440 volts. From these were determined: the effective output $N_{eff} = \frac{Qh1000}{75.3600}$ e.h.p., the electric input $\frac{ei}{1000}$ k.w., or $N_{el}\frac{ei}{736}$ h.p., and overall efficiency of pump and motor $\eta = N\frac{N_{eff}}{N_{el}}$ It was found that on the average a single pump had an efficiency of about 15, two pumps 26 and three pumps 34.5 per cent. It appears therefore that the extraordinarily low efficiency of a single pump improves when two or more

pumps are placed in parallel, and with three pumps the efficiency becomes nearly double. The cause of this lies in the following: the pressure heads of a pump are not static but are used to overcome resistance and may therefore be expressed as $h = kv^2 = \beta Q^2$, where β depends on the piping; actually, from Table 2, it follows that β varies from 0.00057 to 0.00059, or, on the average, is 0.00058. Pressure heads and amounts of water, as long as the resistance in the piping is not changed, for example, by the shifting valves, give therefore parabolic curves. If, further, on the same diagram be plotted the characteristic curve of the pump, that is, the delivery curve for various delivery heads, at the points of intersection of the characteristic curve with the parabola, would be obtained the respective values for the pressure head and amount of water. Since one may assume that the pumps placed in parallel take part in the delivery at the same time, one obtains three points of the characteristic; for each pump, when h is equal to 2.3, 4.8 and 7.6 m., Q is equal to 63, 45.5 and 38 cu. m. per hour respectively. Thus

TABLE 2 DATA OF TESTS OF THE KREMSIER HOSPITAL HEATING PLANT. *A* PUMP CIRCULATION

No. of Test	Number of Pump	Water Circulated, per Hour, Cbm./Cu. Ft.	Pressure Difference h, M./Ft. of Water	$10\beta = 10^4 \frac{h}{Q^2}$	Effective Output, $\frac{1000\,Qh}{3600 \times 75}$ H.p.	Current i, Amp.	Electrical Input, $\frac{ei}{736}$ H.p.	Efficiency, $\eta = \frac{N_{eff}}{N_{el}}$ Per Cent.	Cost of Current E, Marks per Hour	For a Difference of Temperature between Direct and Return Flow of: 14 Deg. Cent.—25.2 Deg. Fahr. Heat Supplied per Hour, WE/B.t.u.	Cost of Coal K, Marks per Hour	$\frac{E}{K}$ Per Cent	25 Deg. Cent.—45 Deg. Fahr. Heat Supplied per Hour, WE/B.t.u.	Cost of Coal K, Marks per Hour	$\frac{E}{K}$ Per Cent
1	1	63/2224	2.3/7.54	5.80	0.54	5.75	3.43	15.6	0.60	882,000/3,501,540	3.56	16.9	1,575,000/6,252,750	6.37	9.5
2	2	63/2224	2.35/7.54	5.93	0.55	5.9	3.52	15.6	0.62	882,000/3,501,540	3.56	17.2	1,575,000/6,252,750	6.37	9.7
3	3	62/2188	2.25/7.23	5.85	0.52	6.5	3.88	13.3	0.68	868,000/3,445,960	3.51	19.3	1,550,000/5,973,500	6.27	10.8
4	1 and 2	90/3178	4.6/15.08	5.68	1.53	9.8	5.85	26.2	1.02	1,260,000/5,002,200	5.10	20.0	2,250,000/8,932,500	*10.91	11.2
5	1 and 3	90/3178	4.7/15.41	5.80	1.57	10.0	5.98	26.3	1.05	1,260,000/5,002,200	5.10	20.5	2,250,000/8,932,500	*10.91	11.5
6	2 and 3	94/3319	5.2/17.05	5.89	1.81	11.15	6.67	27.2	1.16	1,343,000/5,331,710	5.45	21.4	2,350,000/9,329,500	*10.95	12.2
7	1, 2, and 3	115/4060	7.65/25.08	5.80	3.26	15.8	9.45	34.5	1.65	1,610,000/6,391,700	6.51	25.4	2,875,000/11,413,750	11.61	14.2

* The original has 0.91, 0.95 respectively.

over the first characteristic plotted may be the efficiency curve. From the above it follows that the cause of the low efficiency of pumps running singly lies in the fact that their resistant head is too small while the delivery head must have to be designed large in order that the pump should not stall when placed in parallel. This could be obviated only by using for small amounts of water a small pump with a small delivery head, and for large amounts a large pump with a large delivery head, but even then the efficiency would not exceed 25 to 30 per cent.

The jet apparatus have given results shown in Table 3. The value of $\beta = \frac{h}{Q^2}$, which represents the resistance in the piping, is on the average equal to 0.00056, that is, less than in the pump plant. The noise in the apparatus is very small and hardly noticeable even at a small distance. The system has been at work since January 1913 and has given complete satisfaction. As compared with the pump system, the jet system has the following advantages: the expense for the electric current, which amounts to about 15 per cent of the coal bill, is eliminated owing to the absence of moveable parts. The working of the system is extremely simple and reliable. The installation and maintenance cost of the jet apparatus is lower than in the case of pumps and electric motors. Since the circulation does not require power, the main pipes may be made of considerably smaller diameter, which means lower cost of installation and insulation of the pipes as well as lower losses through radiation, owing to decreased surface of the pipes. The use of the jet apparatus is, however, limited by the fact that it requires high pressure boilers. They work as efficiently as hot water boilers, but must have an installation of their own, and therefore jet apparatus for heating purpose can be efficiently applied only in large plants.

Machine Shop

NUT LOCKS (*Les freins d'écrous*, L. Letombe. *Mémoires de la Société des Ingénieurs Civils de France*, ser. 7, vol. 67, no. 2, p. 219, 8 pp., 11 figs. *d*). The Cheneau nut lock consists of a steel wire bent spirally arranged in a way such as to tighten with a certain initial tension over the thread both of the bolt and the nut. The upper and lower ends of the wire are bent at right angles towards the bolt; the end of the wire coming from the uppermost spiral is long enough to pass into a hole previously drilled in the nut. The nut, therefore, carries with it the wire brake during the screwing as shown in Fig. 3. Since the resistance of the wire to friction when passing over the thread of the bolt

TABLE 3 DATA OF TESTS OF THE KREMSIER HOSPITAL HEATING PLANT. *B* JET APPARATUS

No. of Test	Jet Apparatus No.	Steam Pressure, Atmospheres Gage	Amount of Water per Hour, Cbm./Cu. Ft.	Pressure Difference h, M./Ft. of Water	$10\beta = 10^4 \frac{h}{Q^2}$	$N_{eff} = \frac{1000\,Qh}{3600 \times 75}$ H.p.	Temperature in Front and Behind the Jet Apparatus, Deg. Cent./Deg. Fahr. t_1	t	$t - t_1$ Deg. Cent./Fahr.	$a = \frac{t - t_1}{\sqrt{h}}$	Position of Regulating Needle
8	1	5.6	81/2860	3.6/11.8	5.50	1.20	47.5/117.5	57.5/135.5	10/18	5.26	slightly throttled
9	1	5.3	94/3319	4.7/15.4	5.32	1.64	48/118.4	60/140	12/21.6	5.53	wide open
10	1	5.5	56/1976	1.8/5.8	5.76	0.37	48/118.4	58/136.4	10/18	7.47	throttled
11	2	5.4	97/3425	5.0/16.4	5.31	1.80	48/118.4	61/141.8	13/23.4	5.81	wide open
12	2	5.6	80/2825	3.5/11.5	5.47	1.04	48/118.4	59/138.2	11/19.8	5.89	throttled
13	3	5.2	95/3355	4.7/15.4	5.22	1.65	48/118.4	60.5/140.9	12.5/22.5	5.77	wide open
14	3	5.5	80/2825	3.4/11.2	5.32	1.01	48/118.4	59.5/139.1	11.5/20.7	6.25	throttled
15	2 and 3	4.8	172,6073	{ too small	....	....	48.5/119.3	63/145.4	14.5/26.1	....	....
16	2 and 3	4.9	142/5013	{ to be read	....	....	50/122	64/147.2	14/25.2	....	throttled

results in loosening the spirals of the wire, there is no trouble in tightening the nut, but if at any time it should be desirable to turn the nut the other way, the spiral, in tightening, provides such an effective braking that it is necessary to break the wire before it can be loosened. Therefore, when it is desired to loosen the nut, the wire must first be turned loose, which may be done simply, as shown in Fig. E. All that is necessary to permit use of the Cheneau brake is to drill a hole in the nut, and in order to do that a special templet, shown in Fig. F, may be used.

UNIVERSAL RECTIFIER (*Rectificateur universel. Omnia,* vol. 9, no. 431-14, p. 210, April 4, 1914. 1 fig. *d*). The universal rectifier was designed to restore the cylindrical shape of any piece deformed by usage owing to its having been made in two parts. It may be used practically in any case and is based on the principle of continuity. The piece rectified is held between the two jaws of the apparatus and these are brought closer together by means of screws shown in the drawing. One jaw has a roller *E* (Fig. 4) and another a knife edge *F*. When the distance between the jaws is considered to be sufficient, the rectifier is turned round by the handles *D*, somewhat like a capstan, and in a few minutes the piece is made perfectly cylindrical.

Materials

COMPARATIVE TESTS OF PROCESSES FOR IMPREGNATING MINE TIMBER (*Vergleichsversuche mit Imprägnierungsverfahren für Grubenholz,* O. Dobbelstein. *Glückauf,* vol. 50, no. 16, p. 611, April 18, 1914. 7 pp., 11 figs. *e*. Cp. Jahresbericht des Vereines für die bergbaulichen Interessen im Oberbergamtsbezirk Dortmund für 1913, Essen 1914, p. 162). By request of mine owners, the council of the Association of Mining Interests in the Dortmund mining section, in 1912, made some comparative tests of various methods of wood impregnation in common use, to determine among other things in how far impregnation of mine timber is economical. The circular inquiry elicited data which showed that notwithstanding the increased application of iron and reinforced concrete for mine structures in the Ruhr coal region, wood impregnation was still of considerable importance. For the tests pine wood was used of dimensions to suit the available impregnating tank, 1.9 to 1.5 m. (74 to 59 in.) long and 15 to 16 cm. (5.9 to 6.2 in.) in diameter. The article describes in detail the experimental arrangement and apparatus used.

The tests were made with the following materials: the basilit process, in which a salt is used consisting of 88 parts of sodium fluoride and 12 parts of dinitrophenolanilin (a 1.67 per cent solution, 2 deg. Bé. and a temperature of 11 deg. cent. (or 51.8 deg. fahr.). The next test was made with a process in which a 2.4 per cent solution of oxymercurichlorphenolsodium and sodium sulphate, commercially known as Bayer salt. Next tests were made on impregnation with mercury silicate consisting of a mixture of 1 kg. sublimate, 76 kg. of water glass, 0.71 kg. of ammonia and 1 cu. meter of water. A special salt known in trade as Glückauf was also used consisting mainly of nitrated phenols, as well as tests with the well-known Rüping process of tar-oil impregnation; also, with a substance known as mykantin, consisting of 24 per cent dinitrophenol salts, 36 per cent ligninsulphate salts and 40 per cent water and impurities. The article gives detailed data and costs with reference to German conditions. The impregnated pieces were sent into four different mines, each mine receiving at least one piece from each process tested and arrangements have been made for the determination of temperature and moisture as well as for gas analysis at stated intervals.

In a year's time the testing committee will inspect all the test pieces and make a report on the condition of the pieces, and will establish the inflammability of the timbers, ignition

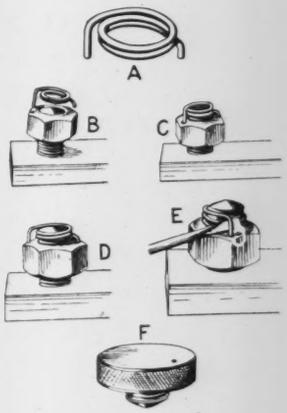


FIG. 3 CHENEAU NUT LOCK

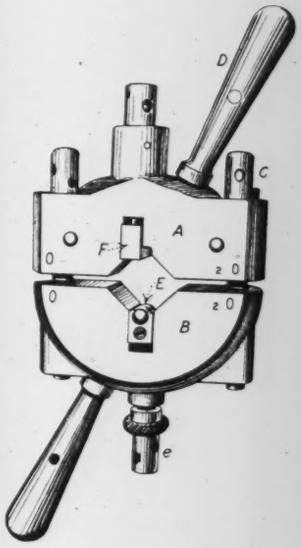


FIG. 4 UNIVERSAL RECTIFIER

point and time taken until full combustion starts. Five years from the beginning of the test the timbers will be sent to a testing laboratory and there tested for mechanical strength and inflammability.

Mechanics

CONCERNING THE USE OF JET APPARATUS AS MIXING MACHINES (*Zur Verwendung der Strahlapparate als Mischmaschinen,* Oskar Nagel. *Chimiker-Zeitung,* vol. 38, no. 48, p. 513, April 21, 1914. *p*). Jet apparatus have recently been rather widely used for delivery of liquids and gases. Their great advantage consists, of course, in the fact that they have practically no moving parts, and therefore permit easy and safe handling, as well as that they are free from breakage. On the other hand the mechanical efficiency of such

apparatus is very low on account of the fact that nearly 75 per cent of the energy of the jet issuing from the nozzle is lost in the eddies created in front of the second nozzle, from which gas or liquid delivery is coming. This amount of energy is consumed in mixing the active fluid with the fluid delivered. This large loss does not matter so much where the jet apparatus is used only intermittently, that is say for a few hours a day or a week. Nevertheless, it appears that it is primarily not a delivery apparatus at all, but a mixing device. In the present article, the author suggests its use as such, especially in connection with the chamber process of producing sulphuric acid, where at present the chambers have to be large to permit of intimately mixing the gases.

This difficulty can be overcome with the steam jet apparatus, and the arrangement which the author suggests consists in having all the gas pass through several jets, to be delivered into the chamber by means of a steam jet apparatus which would produce a very intimate mixture between the gas and the steam. In order to make the eddy action of the apparatus as thorough as possible, he advises that before the gas enters the apparatus the pressure be reduced to below atmospheric pressure. With this arrangement the highest efficiency of the mixing process may be obtained, 1 kg of steam at 2 atmospheres pressure delivering through the nozzle 20 cbm. of gas, and since considerably less steam is thus required for the jet apparatus than for the formation of sulphuric acid, additional steam may be introduced into the chamber either by means of a second large jet apparatus, in which case it would produce an increase of draft, or by injecting a certain amount of water directly into the chamber. The author points out also that an atomizing nozzle may be used to a certain extent as a mixing nozzle or as an absorption apparatus, but when an atomizing nozzle is used for this purpose, it should be enclosed in an appropriate casing arranged in such a manner that every gas particle be compelled to pass through the liquid enclosure.

A Hydrodynamic Experiment (*Expériencé d'idrodynamique,* D. Riabouchinsky. *Il Bollettino dell'Aero Club di Roma,* vol. 9, no. 1, March 1914, p. 7. 1 p., 2 figs. *e*). The author has previously found that a rectangular plate immersed in water cannot be given a movement of self rotation while the same plate will rotate with great energy in air. This difference could not be ascribed to the influence of viscosity since in his experiments he dealt with currents of water and air, the respective velocities of which were proportional to the kinematic viscosities of these two fluids. The next supposition was that this phenomenon depended on the moment of inertia of the plate. In accordance with the method of variables of zero dimension, we have here

$$\frac{nr}{v} = f\left(\frac{c}{\rho r^2}\right)$$

where n is the number of revolutions of the plate in a unit of time, r one of its linear dimensions, c moment of inertia of the plate, ρ density of the surrounding medium, v velocity of the current and f a function which is to be determined. It appeared theoretically probable, however, that even should the moment of inertia of the plate be increased in proportion to the density of the surrounding medium, the plate would remain quite stable and normal to the direction of the current, and it is only with considerable effort (while using high velocities of flow) that one could succeed in forcing the plate to abandon this position, to which, however, it would rapidly return.

In order to test experimentally this assumption, the author constructed the apparatus shown in Fig. 5 A. A rectangular sheet plate *a* (0.3 x 0.075 m., 11.8 in. x 2.95 in.) has an axis *b* which rotates with very little friction in a ball-collar thrust-bearing *c* while the moment of inertia of the entire system may be varied by shifting the lead cylinders *dd*. Experience has shown that vanes of this kind immersed in a current of water could be easily given a movement of self rotation and that the rotation of the plate was the more uniform, the greater the moment of inertia of the system. If the moment of inertia of the system is not large, the eye can distinguish in the motion of the plate a noticeable angular acceleration every time the plane of the vane in running before the current passes into the third quadrant (Fig. B). The *minimum* moment of inertia at which the motion of self rotation begins, without becoming stable, may be approximately estimated as being equal to twice the moment of inertia of a circular cylinder of water having a length equal to the length of the plate and a basis with a

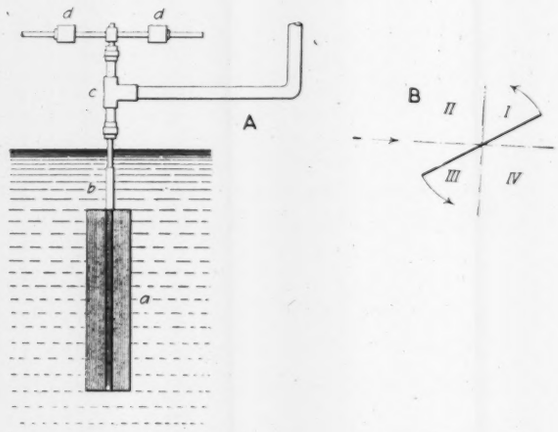


Fig. 5 Apparatus for Establishing Conditions of Self-Rotation of a Plate Immersed in a Liquid

diameter equal to the width of the plate. In order that a plate should turn continuously, the moment of inertia of the system must be equal to at least five times the moment of inertia of such a cylinder.

Railway Shops

New Furnace for Systematic Heat Treatment of Tires (*Novaya metodichskaya pech dla termicheskoy abrabotki bandajey,* B. Grum-Grzimaylo. *Journal of the Russian Metallurgical Society* (in Russian), no. 6, 1913, p. 706, *d*). The furnace for mass production of tires must satisfy the following requirements: (*a*) Each tire must be equally heated all along its circumference. (*b*) All tires in one batch must be heated equally at an equal rate and must remain in the heated state the same length of time. (*c*) When the required temperature has been reached, arrangement must be made for the tire to be taken out easily and rapidly so as to undergo the operations required by its treatment and the cooling required.

The furnace described in the present article is said to be able to satisfy all these requirements. The tires laid one over the other are placed on the platform of a crane which acts also as the bottom of the furnace (inverted flame). The gases are produced in a special furnace and travel as shown by the arrows, passing gradually downwards and encircling

the column of tires both inside and outside. The uppermost tire is heated up to the required temperature (registered by a thermometer), while the lower tires are being prepared. When the uppermost tire becomes hot enough, it is taken out through a window made in the wall of the shaft at the level of this tire. At the same time a new cold tire is introduced into the furnace, which is done in a very simple manner. Owing to the convenient form of the tire and presence of the flange, the entire column can be easily clamped side-wise by three clamps and held suspended while the bottom of the furnace is lowered by a crane. A new tire, Fig. B, is placed on the bottom, which is then raised, the clamps removed and the entire set of tires raised up by the height of one tire. In this position the upper tire will take the place of one which has just been removed, while the latter is treated as required. If full heat treatment with annealing is required, a second furnace may be installed for the annealing part but this furnace does not have to be heated at all. On the contrary cold air will be admitted from below, will cool the lowest tire, gradually rise upwards, and escape through the opening in the dome, provided by a throttle regulating the rate of cooling of the tires. The tire which is to be cooled will be placed

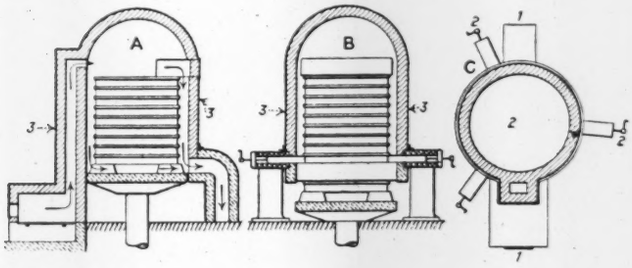


Fig. 6 Continuous Furnace for Heat Treatment of Tires

in the second furnace on top and will be removed from below by means of clamps and a crane. This furnace provides for a systematic, absolutely uniform heating of tires at the rate equal for all tires and also permits of measuring conveniently the temperature of the heated tire. In this way it permits a continuous mass production of tires, heated and treated in an absolutely uniform manner.

Steam Engineering

Concerning the Determination of Efficiency of Blast-Furnace Gas Boilers (*Zur Ermittlung des Wirkungsgrades von Hochofengas-Dampfkesseln. Stahl und Eisen*, vol. 34, no. 16, p. 674, April 16, 1914. 3 pp., 2 figs. *p*). The heat consumption of a blast-furnace gas boiler is composed of the following three parts: (*a*) Heat usefully consumed, that is, transferred to the water evaporated (efficiency). (*b*) Loss of heat through the flue plus heat carried off in unburned gas particles. (*c*) Loss through radiation and conduction. Other losses which occur in steam boilers, such as losses through soot and grate residues, do not exist in blast-furnace gas heating.

This makes possible a method of determination of the boiler efficiency exclusively by means of analysis and temperature measurement of the heating gases and flue gases. Of the three parts into which the heat consumption of a blast-furnace gas heated boiler is divided, the loss through radiation and conduction is comparatively small and subject to variations only within narrow limits. Of course, no general statement can be made as to its magnitude, which depends in particular cases on the size and construction of the boiler and efficiency of the insulation, but usually it varies between 2 and 10 per cent at normal loads. As a rule one may estimate that in a watertube or firetube boiler, the absolute value of the loss through radiation and conduction varies proportionally to the load, but its relative value changes within narrower limits and perhaps even remains constant; at any rate the value of this source of loss may be determined for each boiler system once and for all by proper tests.

The author believes that even when the load is variable, the loss through radiation and conduction may be estimated correctly to within 2 or 3 per cent, which is entirely satisfactory for carrying out the determination of boiler efficiency in accordance with the present method. The losses through flue gases and incomplete combustion may be very easily determined from knowledge of the temperature and chemical composition of the blast-furnace gas and flue gas, whereupon by knowing the specific heats and heats of combustion of each particular gas, may be determined the losses through free and latent heat of the flue gas referred to one cubic meter of the heating gas. The heating value of the latter is known from the analysis of the blast-furnace gas, and the boiler efficiency appears therefore as the difference between the heating value of the blast-furnace gas on one side, and combined losses through flue gas, radiation and conduction on the other side.

An objection might be raised that the determination of the flue gas losses is uncertain in view of the uncertainty of the data concerning the specific heats of the gases; this however is not quite so. While the values of specific heats of gases may still be considered doubtful at very high temperatures, their values at low temperatures such as occur in the flue of a steam boiler may be considered to be fairly well established (the author gives the table of specific heats of two-atomic gases, water and carbondioxide referred to grammolecule, as determined by Langen, Pier, and Holborn and Henning), the maximum error being between 0.04 and 0.06 of the heating value of the blast-furnace gas. One must not forget also that direct determination of boiler efficiency, when superheated steam is used, is based on the specific heat of steam which also cannot be considered to be fully established.

In order to test the applicability of this process under various conditions, the author considers the following contingencies: (*a*) The amount of gas, its heating value and ratio of gas to air remain constant. (*b*) The amount of gas varies as shown in Fig. 7 A, while the ratio of gas to air during each single phase of load variation remains constant. The same applies to the heating value of gas. (*c*) The amount of gas and ratio of air to gas vary all the time.

Case (*a*) happens only when a certain boiler construction or a certain kind of gas is investigated and the plant is run so as not to be affected by outside influences. In such a case it is sufficient to take one test of the heating gas and flue gas and make one temperature determination for each of them at any time. In case (*b*) the efficiency is determined for each particular phase of load variation as in case (*a*) and the average efficiency is determined in accordance with the formula

$$\eta_m = \frac{h_1 q_1 t_1 \eta_1 + h_2 q_2 t_2 \eta_2 + h_3 q_3 t_3 \eta_3 + \ldots}{h_1 q_1 t_1 + h_2 q_2 t_2 + h_3 q_3 t_3 + \ldots}$$

For the determination of η_m it is therefore necessary to know the amount of gas consumed in each phase. The ad-

vantage, as compared with the direct method of determination, is therefore quite important, since in this process are required not the absolute values but the ratio of the single velocities or single amounts of gas consumed in different phases, and even large errors in the determination of the relative velocity will have only a slight influence on the precision of results. The taking of tests and measurement of temperature may be made at any time during the single phase of load variation, but, of course, only after the plant has come into the normal state of operation, say 1 or 2 minutes after the variation of the amount of gas admitted. Only in the case when the heating value of the gas varies, the taking of tests should be made during the entire duration of the phase. Instead of determining separate gas amounts and efficiencies, and calculating from them the average efficiency, one may also take a continuous sample of blast-furnace gases and flue gases during the entire duration of the experiment and determine the average efficiency from this continuous sampling. In order to make the composition of the test samples correspond absolutely to the average composition of the blast-furnace gas or flue gas, it would be necessary to vary the suction velocity at which the test sample is taken in proportion to the respective velocity of the gases. Actually, however, it is sufficient to vary the suction velocity of the gas samples only in proportion to the velocity of the blast-furnace gas.

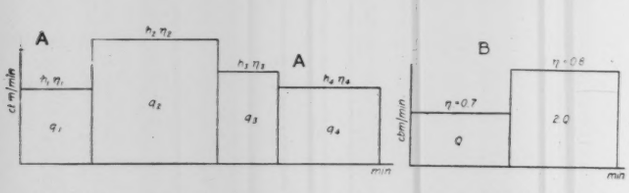


FIG. 7 PHASES OF LOAD VARIATION ON BLAST FURNACE GAS BOILERS

Case (*c*) comes into consideration when the gas pressure varies considerably. The determination of the average efficiency is then carried out, as in the preceding case by continuous suction of test samples of the blast furnace and flue gases.

In order to determine how far the average efficiency as calculated depends on the possible errors in the determination of the relative gas values, the following example is numerically carried through; the gas admission takes place in two phases of load variation in accordance with Fig. 7 B. The average efficiency is therefore

$$\eta_{im} = \frac{Q_x 0.7 + 2Q_x 0.8}{3Q} = 0.767$$

If the velocity of the flue gas in the first phase of load variation has been measured 10 per cent too small and if the second phase 10 per cent too large, the average efficiency will be found to be

$$\eta_{im} = \frac{0.9Q_x 0.7 + 2.2Q_x 0.8}{3.1Q} = 0.776$$

only 0.4 per cent too high.

STEAM CONSUMPTION OF A ROLLING MILL STRAIGHT-FLOW STEAM ENGINE (*Dampfverbrauch einer Walzenzug-Gleichstrom-Dampfmaschine,* H. Ortmann. *Stahl und Eisen,* vol. 34, no. 17, p. 709, April 23, 1914. 2 pp., 2 figs. *e*). The article describes some tests on steam consumption of a straight-flow steam engine used to drive a three high rolling mill. As the work of the mill increased, the engines used to drive were at the time found to be too weak, until finally a large straight-flow steam engine of the most modern design was installed of 1700 mm. bore, 1400 mm. stroke and 100 to 130 r.p.m. This engine is provided with a quiet running automatic valve gear and an independent and very sensitive governing. The speed of rotation remains pretty constant even during rolling and after very large overloads or falls of load it is very rapidly brought to the normal level. The regulation of the engine takes place far more rapidly than was the case with the tandem engine, which is, of course, a result of the simpler construction of the single cylinder engine. The speed, as a rule, is 100 r.p.m., but when small shapes are rolled it may be raised to 130 r.p.m. The boiler pressure with the present boiler is eight atmospheres, but it is proposed to raise it to 12 atmospheres, with corresponding changes in the cylinder. The steam consumption was guaranteed by the manufacturers at 5.2 kg. (11.44 lb.) per i.h.p-hr. at seven atmospheres gage pressure at the engine and 300 deg. cent. (540 deg. fahr.) superheat. The steam consumption at various loads does not vary much. As determined from the diagrams, the steam consumption appears to be as follows:

	Steam Consumption per H.P-Hr.	
At I.H.P.	Kg.	Lb.
2700	5.3	11.66
4000	5.2	11.44
5300	5.45	11.99
6650	6.1	13.42
8000	7.3	16.06

These favorable figures led to a belief that, considering the former steam consumption of 9.5 kg., the new engine would pay for itself in a short time. After the engine had been in operation for about six months it was decided to determine its actual steam consumption, and to do this a brake test was undertaken, with the engine working for three hours at an average rate of output of 3000 h.p. This test was followed by a second test with a load of 1820 h.p. on the engine, which was required in order to establish how consumption varies with variations of load. Every 5 minutes during the tests diagrams were taken. Condenser losses between engine and boiler were taken into consideration in determination of the steam consumption. The condenser plant, located near the engine, is driven by electric motors and consists of centrifugal pumps for handling the water of condensation and an electrically driven air pump. The power consumption of the condenser plant was continuously measured by a recording wattmeter and was found to be 115 h.p. Table 4 gives the test data; since the data obtained during the test referred to a given steam pressure and temperature of superheat, they had to be recalculated in order to find the values of steam consumption for guaranteed conditions.

TABLE 4 DATA OF TESTS OF A STRAIGHT-FLOW STEAM ENGINE DRIVING A ROLLING MILL

	Test 1	Test 2
Average speed, r.p.m.	97.8	102.0
Length of test, hours	3	1.5
Average pressure at the engine, atmospheres gage	6.3	7.03
Steam temperature, deg. cent./fahr.	283/541.4	289.9/553.8
Vacuum, per cent	87.5	89.9
Average output, i.h.p. (continental)*	2982	1822
Steam consumption, as measured, without condensation, in kg./lb. per i.h.p-hr.	5.83/12.82	4.6/10.12
Steam consumption reduced to 7 atmospheres gage pressure, 300 deg. cent. (540 deg. fahr.) superheat, 90 per cent vacuum, without condensation, in kg./lb. per h.p-hr.	5.3/11.66	4.5/9.9
Power consumption of the condenser plant, per cent	3.9	6.3

* A continental horsepower is equal to 736/746 American horsepower.

High Feedwater Preheating on Steamers (*Hohe Speisewasservorwärmung auf Dampfern,* Offerdinger. *Zeits. des Vereines deutscher Ingenieure,* vol. 58, no. 16, p. 617, April 18, 1914. 5 pp., 2 figs. *deA*). The author presents a new method of preheating boiler feedwater particularly adapted to use on steamers. He proposes to preheat the water by exhaust steam from auxiliary engines and receiver steam to a temperature of 140 deg. cent. (284 deg. fahr.) and higher. The advantage of such high preheating of feedwater lies first in the improvement of the efficiency of the engine plant, and second in the beneficial action on the life of the boiler, which is in this way spared from the heavy stresses consequent upon the injection of comparatively cold water. In addition, the higher the temperature of the water the freer it is from air, which is objectionable when present in the boiler. For such high preheating of the feedwater two-stage preheaters in series are used, working on steam of different pressures. When such preheaters are used in connection with triple or quadruple expansion engines, they may first be heated by the exhaust steam from the auxiliary engines with an addition of steam from the low pressure receiver. From this preheater the water passes into the second element, where it is heated by the steam from the intermediate pressure receiver, the pressure of the steam in the second element being maintained at a higher level than in the first preheater, i.e., at about the same level as the pressure in the intermediate pressure receiver. Fig. 8 shows the arrangement of such two-stage preheaters, where the entire set is inserted into the pressure piping of the feed pump, although the first preheating stage might also be inserted into the suction piping of the pump. In general, however, it would appear to be advisable to make both preheating elements of equal size and construction and to place them on to the pressure piping, providing them with means for air and oil separation. To regulate the pressure of the heating steam in the second stage, a throttling valve is provided so arranged that the water of condensation of the heating steam, but not the steam itself, is allowed to pass. In order to avoid heat losses the entire water of condensation from the heating steam must pass into the suction piping of the feed pump or the tank of the air pump. If the feed pump is of the plunger piston type it is advisable to lead the water of condensation from the heating steam of the second preheater stage not directly to the suction side of the feed pump but into the heating steam space of the first preheater stage, in order that it should give up there as much as possible of its heat before it reaches the feed pump together with the rest of the water of condensation from the first preheater stage. In this way the feedwater at the suction end of the pump remains comparatively cool notwithstanding the high degree of preheating on the pressure side of the pump, which is of importance for the good working of the feed pump.

The following tests were made to show the advantages derived from higher superheating of feedwater by two-stage preheater arrangement involving the use of steam from an intermediate pressure receiver. The boiler was provided with artificial draft (Howden process) and Schmidt superheaters and had the following dimensions: heating service of boiler in contact with water, 396 qm.; grate area, 95 qm. (1021 sq. ft.); heating service of superheater in contact with steam, 182 qm. (1959 sq. ft.); and steam pressure 13.5 atmospheres. The main engine was a triple expansion vertical marine engine with surface condensation and pumps driven by connecting beams and had the following dimensions: stroke, 1050 mm. (41.3 in.); diameter of high-pressure cylinder, 600 mm. or 23.6 in.; intermediate cylinder, 970 mm. (38.1 in.); and low-pressure cylinder 1575 mm. (61.8 in.). The two-stage feedwater preheater was inserted into the pressure piping of the feed pump, the heating area in either stage being 7.5 qm. (80.7 sq. ft.), thus making a total of 15 qm. (161.4 sq. ft.)

Two tests have been made. In test A the plant was run with preheating of feedwater by exhaust steam from the auxiliary engines and receiver steam from the low-pressure receiver in the first stage and by intermediate pressure receiver steam in the second stage. In test B, the plant was run in the same manner as in test A, but the heating steam from the intermediate pressure receiver was cut off and only the first stage of the preheater was working (in the same manner as in test A). The degree of admission in the steam

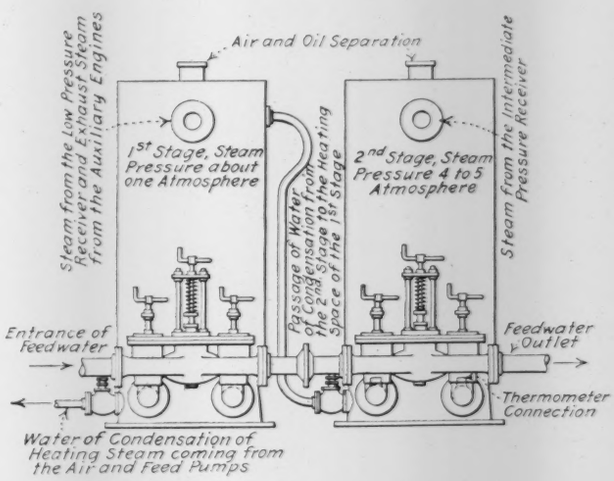


Fig. 8 Two-Stage Feedwater Preheater

cylinder was the same in both cases. The data obtained in the tests are shown in Table 5, while Table 6 gives the comparison of the data of the two tests recalculated. The feedwater in the first test was heated to 126 deg. cent. (258.8 deg. fahr.) and in test B to 79 deg. cent. (174.2 deg. fahr.). No measurement of coal consumption was made, but the water returned by the feed pumps to the boiler was measured by a water meter of the Kegler type. The heat consumption calculated from these values gives a more reliable basis for the estimation of the operating conditions present than would be possible to make from the measurement of coal consumption. During the tests A and B no auxiliary feedwater was admitted. The heat consumption figures per indicated horsepower-hour given in Table 6 seem to be too good, but, for the purpose of comparison between the two, this does not matter. Heat losses which occur during the test may be assumed to be distributed evenly over the entire duration of the tests. During both tests the ventilation machinery, steering gear engine, and ash-hoist were driven by steam, the ventilation constantly, steering gear as necessary, and the ash-hoist to lift from 22 to 24 buckets at each test; the weather was good, the sea nearly quiet and the steering gear engine only little used. The author reports also control data obtained from an investigation of indicator

diagrams taken during the same tests. Both methods indicated a heat saving of from 3 to 4.2 per cent when the temperature of feedwater is maintained at from 126 to 136.5 deg. cent. (258.8 to 277.7 deg. fahr.). The cause of the heat saving lies in the high latent heat of steam. The steam from the intermediate pressure receiver proceeds to do further work in the intermediate and low-pressure cylinders

TABLE 5 DATA OF TESTS OF FEEDWATER PREHEATING, ONE AND TWO STAGE

	Test A	Test B
Duration of test, hours	3	3
Admission, per cent		
High-pressure cylinder	62	62
Intermediate cylinder	37	37
Low-pressure cylinder	42	42
Steam pressure, atmospheres		
Boiler	13.8	13.7
High-pressure receiver	13.1	13.0
Intermediate pressure receiver	5.65	6.05
Low-pressure receiver	1.69	1.70
Condenser	0.15	0.15
Steam temperatures, deg. cent./fahr.		
Superheater	285/545	295/563
High-pressure receiver	268/514.4	278/532.4
Intermediate pressure receiver	214/417.2	222/431.6
Low-pressure receiver	113/235.4	115/239
Water temperatures, deg. cent./fahr.		
Suction piping of feed pumps	43/109.4	48/118.4
Pressure piping of feed pump, first preheater stage	67/152.6	76/168.8
Pressure piping of feed pump, second preheater stage	126/258.8	79/174.2
Suction piping of circulation pump (sea water)	11/51.8	10/50
Pressure piping of circulation pump at exit from condenser	50/122	51/123.8
Air temperature in the machine room, deg. cent. /fahr	28/82.4	30/86
Boiler draft in the air duct at the fan, mm. of water	30	30
Engine output in indicated h.p.		
High-pressure cylinder	430	371
Intermediate cylinder	395	443
Low-pressure cylinder	440	444
Total	1265	1258
Speed, r.p.m.	74.3	74.4
Ship speed as measured by log, knots	10.7	10.8
Quantity of water, as indicated by meter, liters/gal.	20620/5493	18870/4983
Quantity of feedwater, kg./lb.	19362/42596	18332/40330
Specific weight of water at 126 or 79 deg. cent. respectively	0.939	0.972

TABLE 6 RECALCULATED DATA OF TABLE COMPARED

	Test A	Test B
Boiler pressure, atmospheres	13.8	13.7
Steam temperature in superheater, deg. cent /fahr.	285/545	295/563
Average engine output, i.h.p.	1265	1258
Steam consumption		
Total, kg./lb.	19362/42596	18332/40330
per h.p-hr.	5.102/11.22	4.86/10.69
Heat generation, WE/B.t.u.		
of steam coming from the superheater	721.3/2863.5	726.6/2884.6
of feedwater from the boiler	126/490.2	79/313.6
Heat supplied to working fluid in boiler and superheater, WE/B.t.u.		
(*a*) per kg./lb. of feedwater	595.3/1071.5	647.6/1165.6
(*b*) per i.h.p-hr	3037/5466.6	3147/5664.6
Saving in heat in test A as compared with test B, per cent	3.5	

of the engine (having regard to the heat which reaches a boiler with the feedwater) at thermal efficiency of about 12 per cent, while the steam which is taken from the intermediate pressure valve casing and used for the higher preheating of the feedwater is returned to the boiler with the utilization of at least 90 per cent of its heat. This difference in the efficiency of utilization of part of the steam accounts for the better saving of heat with the two-stage preheater.

SURFACE COMBUSTION FOR BOILER HEATING (*Die flammenlose Oberflächenverbrennung zur Kesselbeheizung,* O. Dobbelstein. *Glückauf,* vol. 50, no. 14, p. 525, April 4, 1914, 11 pp., 10 figs. *de*). This article is based on the work of the German commission on coke ovens, which, in connection with the Dortmund Association for the Inspection of Boilers, has carried out a series of tests on surface combustion boilers at which the inventors, Prof. W. Bone and R. Schnabel, were represented. The tests are prefaced by a brief description of the surface combustion boiler and improvements which the German manufacturers are proposing to make in them. One of such improvements is the construction of a more condensed type of machine containing in itself a preheater and superheater, the latter being heated by a mixture of air and gas, burned in a loosely thrown fireproof mass as shown in Figs. 9 A and B, the gases of combustion combining with the boiler flue gases and passing out through the preheater *v*. Instead of sensitive gas cocks pipes of a cross-section practically equal to those of the fire tubes are used which the gas enters laterally, and the air from the rear. Not the gas admission but that of the air of combustion is regulated by means of ring valves set in the rear part of the tubes. The gases come through the main pipe *z* and divide in front of the boiler through four horizontally placed side by side branches with small cross-section. These branch pipes pass between the extension of the fire tubes and supply with gas each one of the two fire tubes. The lowest branch pipe is an exception, however, since only the second lowest row of fire tubes (see Fig. C) is connected with it. The lower five fire tubes, *aa*, have no supply of gas and air mixture, but are heated by exhaust gas coming through pipe a_2 from the separately heated superheater. In addition there are provided a smaller number of fire tubes, probably about 60, having a larger cross-section and being about 3 m. long. This arrangement is provided for the case when hot feedwater is already available. On the Hanover mine the boiler is heated by coke-oven gas having a heating value of about 4000 WE (7600 B.t.u.), previously passed through the benzol separating plant, but not freed from hydrogen sulphide nor cyanogen. After about three weeks of operation it was found that the fire clay filling in the front end pipes, on account of the high temperature prevailing, was partly melted and partly broken up. It was also found that the output of the boiler, which was initially about 60 kg./qm. of heating surface, had decreased considerably because the porous mass in the fire tubes of the preheater became clogged up, partly through deposits and partly owing to sulphurous formations, so that the exhaust notwithstanding a larger consumption of power could not supply a sufficient amount of gas and air mixture. This led to renewal of the porous mass both in the fire tubes of the boiler and those of the preheater after which the first real series of tests had been started. Several of these tests quoted in the article may be considered only as preliminary, since during the performance adjustments of the gas cocks and even alterations in the arrangements were made. The results of tests during some of the days were remarkable: The first day, during an 8-hour test, an output of 61.7 kg./qm. of the fire tube surface was obtained with considerable variation of the gas pressure at the beginning of the test. The next day when this inconvenience was eliminated, the output rose to 66 kg./qm. The efficiency of the boiler was 93.3 per cent and that of the preheater 3.9 per cent. If one takes the steam consumption of the elec-

trically driven exhaust fan, including all losses, as 10 kg. per h.p-hr., the total efficiency, including the preheater, would be about 89 per cent with a moisture in the steam of about 2.5 per cent average. These outputs would represent an important advance if they could be maintained for regular operation, which, the article states, is not yet possible. After 14 days' run the residues in the fire tubes of the preheater, owing to the clogging of the porous mass, had already increased to such an extent that the boiler had to be shut down in order to clean the fire tubes. It is now intended to take out the filling from the tubes of the preheater entirely and then establish the fall of efficiency. After several months of operation, the tests will be repeated in order to establish whether a further fall of efficiency occurs owing to the decomposition of the fire clay filling in the fire tubes of the boiler. After three months of operation the boiler and preheater have been opened in order to see if there was any scale formation and to take out the fire clay from the fire tubes. It was found that during this run of the boiler, estimated at about three months, in the front end of the fire tubes in the boiler a thin, hard layer of scale was formed, which in the rear ends of the pipes reached a thickness of 4 to 5 mm. The copper pipes of the preheater were strongly attacked so that they had to be replaced by new pipes. The attacking of the pipes was due to the fact that when the gases of combustion were cooled down in the preheater to about 90 to 110 deg. cent. (194 to 230 deg. fahr.), the sulphurous acid had an opportunity to unite with water and thus form sulphuric acid, which naturally strongly attacked the copper of the pipes. The analysis has shown that in the mass taken out from the pipes there was 57 per cent copper sulphate and 10 per cent iron sulphate. Therefore the cooling down of the gases of combustion to the temperatures of 90 to 110 deg. cent. (194 to 230 deg. fahr.) is to be rejected for operating considerations, especially as the gain in heat is only from 2 to 3 per cent, while the loss through the increased power combustion of the exhaust practically reduces to nothing whatever is gained by reduction of the temperature to so low a level. The copper pipes have been replaced by cast-iron pipes, which was done especially because the use of the more expensive material did not appear to secure any corresponding advantage. The fire tubes of the boiler were filled with new fire clay mass and new tests made. It must be borne in mind, however, that the gas pressure could not be maintained at the same level as in the second test, and as a result both the gas combustion and boiler output were about 5 per cent below that of the former test. With coke-oven gas firing in this type of boilers with numerous fire tubes in regular operation, one cannot hope to obtain more than 60 kg. of steam per hour per 1 qm. of the heating surface, since the available gas pressure is not usually more than 100 mm. (4 in.) of water. Whether special apparatus to increase the gas pressure would prove to be economical or advisable remains as yet to be seen.

Here, as in all systems of gas firings, it is important to maintain as uniform a gas pressure as possible, since only in this case the admission of air can be maintained so as to have the combustion preceded by the slightest possible excess of air. In this connection the fireproof filling of the pipes may be improved, even supposing that as it stands it could withstand operation for a length of time at the high temperature used. Owing to the irregular form of the separate pieces it is extremely difficult to make the filling so that the resistance in all of the pipes shall be equal. The Berlin-Anhalt Machine Company is therefore working on the preparation of a special uniform filling made up of pieces of refractory material of the same size. This will make it possible to place filling in such a manner as to maintain the resistance practically uniform in all the pipes, while the total resistance will be materially reduced, and this will lead to a reduction in the power consumption of the exhaustor and raise the efficiency of the plant. These tests have further shown that for ordinary metallurgical practice the construction of the boiler with numerous fire tubes is not suitable since they require quite a large amount of attendance. The above mentioned concern is therefore endeavoring to reduce the number of tubes in their new boilers, and it is considered possible that later on ordinary fire tube boilers can be converted into surface combustion boilers. This would materially increase their output, and further, the conversion of a fire tube boiler into a surface combustion boiler would eliminate the objection made to the Bone boiler in that its water space is too small and that it has too low a reserve of steam.

The tests described also included tests on the application of tar oil in surface combustion boilers, for which purpose the experimental boiler shown in Figs. D and E has been used. It was designed to work at 12 atmospheres gage pressure and had a diameter of 1.3 m., and a length of 1.7 m., provided with 37 fire tubes of 76.5 mm. inside diameter, thus constituting a total heating surface of 12 qm. Immediately connected with the boiler there is a preheater, *c*, also enclosing fire tubes and supplemented by a second preheater, *d*, of the same construction, the installation of which was required because a single preheater utilized the heat of the flue gas sufficiently; in front of the firebox and partly inside it has been placed a combustion chamber, *a*, lined with refractory material and connected with the firebox of the boiler by means of slots in its refractory jacket. Over the boiler is located a wooden shed, on the roof of which is placed the tar oil supply tank from which the oil flows automatically into the boiler after being preheated by exhaust steam to about 90 deg. cent. (194 deg. fahr.), to distribute itself into three nozzles, *b*, set in the front wall of the combustion chamber. The electrically driven fan provides the air of combustion, the pressure of which is sufficient to atomize the tar oil and to overcome the resistance of the fire tubes.

Previous to each test the boiler was maintained in operation for about 2 hours, this time being sufficient, on account of the small content and consequent rapid heating, to bring the boiler into its normal state of operation. The tar oil and feedwater were weighed, the feedwater being also checked by means of a Siemens water meter; the readings of pressure, temperature and power consumption at the fan were taken at regular intervals of 15 minutes, the gas analysis being as far as possible taken also at the same intervals. On the whole the tests have shown that on forced runs with surface combustion boilers and tar oil as fuel, outputs up to 120 kg. per hour can be obtained. It is doubtful, however, that the boiler can be relied on to run regularly at such a rate of output, since both after the first and after the third tests it was found that the front tube wall leaked, even though it appeared that the fire clay wall built in front of it would protect it from the immediate action of the fire. On the other hand, it must be remembered that the cooling of

the boiler was very rapid because after the end of the test the oil firing was cut off immediately. It appears therefore that this type of boiler is not suitable for continuous operation when there are many rolled-in connections in the zone of the highest temperatures. The Berlin-Anhalt Machine Company has therefore designed a different type of boiler in which the tar oil comes in through a single nozzle together with the air of combustion supplied by a special fan. The combustion chamber consists of a single cylinder of refractory material, placed in the fire tube. The hot gases enter through the fire clay grating into the third part of the fire tube which is filled with large pieces of fire clay. It is expected that this type will be more suitable for continuous operation than the one shown in Figs. D and E.

The author concluded that neither the coke-oven gas fired boiler nor that using tar oil was suitable for continuous operation, though it was possible that a different design would obviate the present difficulties.

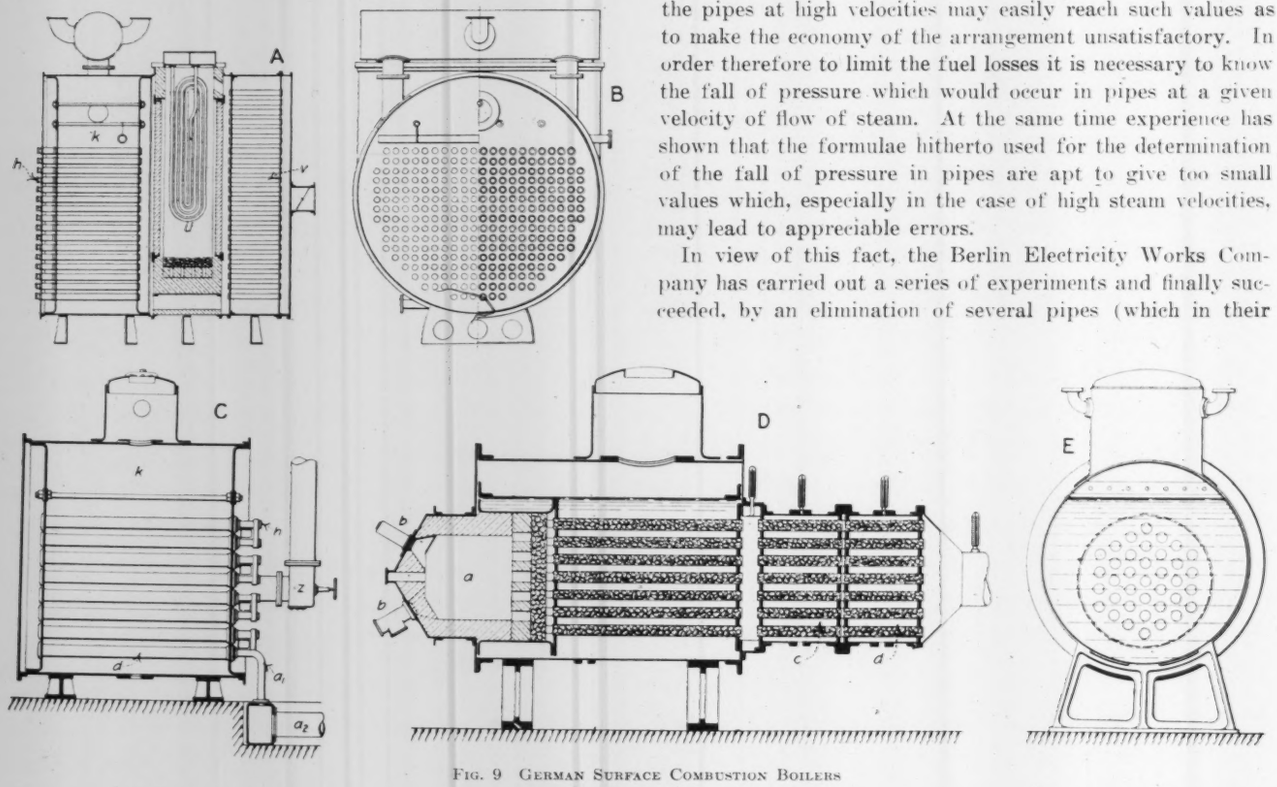


Fig. 9 German Surface Combustion Boilers

Fuel Saving Through Proper Dimensioning of Steam Piping. Investigations on Pressure Fall of Flowing Steam (*Brennstoffersparnisse durch richtige Bemessung der Dampfleitungen. Untersuchungen über den Spannungsabfall des strömenden Dampfes,* M. Guilleaume. *Feuerungstechnik,* vol. 11, no. 14 and following; article not finished. *eA*). Eberle in *Forschungsarbeiten des Vereines deutscher Ingenieure,* vol. 78, has shown that when superheated steam of about 330 deg. cent. (626 deg. fahr.) is flowing heat losses in pipes protected by insulation amount to approximately 1500 calories per qm. (252 B.t.u. per sq. ft.) of the external surface of the pipe. It is therefore of great importance to reduce these losses as much as possible. He has further shown that this constant loss is inversely proportional to the amount of steam flowing through the pipe. It is therefore in the interest of a better utilization of fuel to use as high steam velocities in the pipes as possible, but the intermittent drawing off of steam in the case of reciprocating engines makes it impossible, on account of consideration of safety, to use steam velocities in excess of 25 to 30 m. (82 to 98 ft.). The practically uniform drawing off of steam in most of the turbine systems permits of leaving out of consideration the question of safety, but too high velocities cannot be used there either, owing to the fact that the loss of pressure in the pipes at high velocities may easily reach such values as to make the economy of the arrangement unsatisfactory. In order therefore to limit the fuel losses it is necessary to know the fall of pressure which would occur in pipes at a given velocity of flow of steam. At the same time experience has shown that the formulae hitherto used for the determination of the fall of pressure in pipes are apt to give too small values which, especially in the case of high steam velocities, may lead to appreciable errors.

In view of this fact, the Berlin Electricity Works Company has carried out a series of experiments and finally succeeded, by an elimination of several pipes (which in their time have been put in for the very purpose of reducing the fall of pressure in the system) to obtain a saving in fuel of several thousand marks per year. This was done by taking out certain branches in the piping system which offered an especially high resistance to the flow of steam, substituting for them other pipes of lower resistance. The steam velocity after these alterations could be increased to nearly double its former value and at the same time the fall of pressure was maintained within such limits as would not affect the full utilization of the machinery.

The determination of the fall of pressure in pipes conducting saturated or superheated steam is usually done by means of the following formulae: For straight pipes without bends or valves or other area reducing elements, formula 1 is used:

$$p_1 - p_2 = \beta_1 . \gamma . w . \frac{l}{d} \quad \ldots\ldots [1]$$

where p_1 is the steam pressure at the entrance into the piping and p_2 at the exit from the piping, both in kg./qcm., l is the length of the piping in meters, d inside diameter of the

piping in meters, γ average specific weight of the steam, w average velocity of steam in meters per second and β_1 coefficient of resistance or conductance for smooth pipes. While Guthermuth has determined the value of this coefficient as 15×10^{-8}, Eberle has found that its value is 10.5×10^{-8}. A still different value is that given by Fritzsche, who found that β_1 varies with the diameter of the pipe d and the product $w\gamma$, as follows:

$$\beta_1 = \frac{9.4}{10^7 (\gamma w)^{0.148} d^{0.293}} \quad \ldots\ldots\ldots\ldots [2]$$

and the value obtained by Eberle, corresponds fairly well to that derived from this equation for a pipe with a diameter of 70 mm. (2.8 in.) and $w\gamma = 50$. An experiment of Eberle with the piping of 70 mm. (2.8 in.) in diameter has established the fact that in the case of poppet valves, slide valves, shut-off corks, the resistance of these elements is equal, under similar conditions, to that of a pipe of the same diameter and 16.4 m. (53.8 ft) long. As regards equalization pipes and compensation bends, data of tests of C. Bach and R. Stückle[1] with two pipes, 55 and 100 mm. (2.2 and 4 in.) inside diameter have been published, but whether the coefficient of resistance determined for this case would apply to bends of other diameters or radii of curvature remains to be proved.

In how far all these formulae can be relied on for the determination of the pressure fall in the piping may be seen from the following example: A certain piping system consisted of two parts, namely, one piece 300 mm. (12 in.) inside diameter and 40 m. (131 ft.) long and a second piece joined to it 350 mm. (14 in.) inside diameter and 55 m. (180 ft.) long. Into the first were built in a standard steam stop valve of 300 mm. (12 in.) diameter and a lyra equalization bend with a radius of curvature of 1.2 m. (3.93 ft.) two arcs of 90 deg. and radius of curvature 0.9 m. (2.95 ft.). In the second piece were built in two standard steam stop valves of the same diameter as the pipe, two arcs of 90 deg. and 1 m. (3.28 ft.) radius of curvature. The calculation made in accordance with the above formulae gave, for a steam velocity of 30 m. (98.4 ft.) per second, an average specific weight of steam of 4.8, a pressure fall of 0.168 kg./qcm. (2.38 lb. per sq. in.), while direct measurement under the same conditions has given an actual fall of pressure of 0.59 kg./qcm. (8.38 lb. per sq. in.). When the steam velocity was raised to 55 m. (180 ft.), the pressure fall observed was 2 kg./qcm. (28.4 lb. per sq. in.), while that determined from the formulae 0.56 (7.96 lb. per sq. in.), which shows plainly how little reliable the above formulae are.

The article describes the experimental arrangement used in these tests. The measurement of fall of pressure was made in mm. of mercury by means of a special manometer, and, since the errors of observation are inversely proportional to the pressure differences measured, the experiments were carried out with as high steam velocities as possible. The temperature of water and of the mercury column was taken into consideration whenever the heat radiation might have affected the reading of the manometer. It was found, however, that the points at which measurements were made had to be selected in straight sections of pipe, since when it was attempted to measure the pressure fall inside a valve, the eddies there led to the indicated pressure fall being about 40 to 50 per cent lower. The points of measurement were therefore always selected at about 200 mm. (8 in.) from the flange joint. The velocity of steam was established by meas-

No.	Length	Ins. Dia
1	750	300
2	7850	300
3	7500	300
4	10,000	300
5	10,400	300

No.	Length	Ins. Dia
6	800	300
7	7500	300
8	4750	300
9	5850	300
10	750	300

No.	Length	Ins. Dia
11	3125	300
12	600	300
13	3500	275
14	700	275

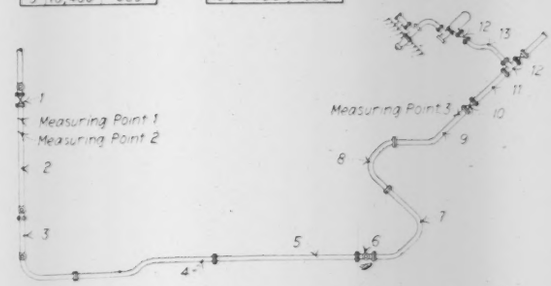


Fig. 10 Diagram of a Steam Piping System showing Points of Measurement of Pressure Fall

TABLE 7 DETERMINATION OF PRESSURE FALL IN STEAM PIPING

No. of Test	Duration of Tests, Min.	Average Pressure in Piping, Atmospheres Absolute	Average Temperature in Piping, Deg. Cent.	v, Average Volume of 1 Kg. (2.2 Lb.) of Steam in Cbm. (1 Cbm. = 35.314 Cu. Ft.)	$\gamma = \frac{1}{v}$	Steam, in Kg. per Hour	w, Velocity of Flow of Steam per Sec., in Piping 300 Mm. (12 in.) in Diameter, in M. (1 M. = 3.28 Ft.)	Pressure Fall in the Piping, $p_1 - p_2$, Atmospheres	l, Length of Piping in M. (1 M. = 3.28 Ft.)	$w.\gamma$	Coefficient of Resistance $\beta_1 = \frac{p_1 - p_2}{w^2 \gamma} \frac{l}{d}$
1	60	13.63	352.0	0.212	4.72	56887	47.35	0.1784	54.25	223.4	9.32×10^{-10}
2	60	12.42	353.0	0.233	4.29	52035	47.65	0.1587	54.25	204.6	9.02×10^{-10}
3	60	11.35	345.5	0.253	3.96	48111	47.73	0.1461	54.25	189.0	8.95×10^{-10}
4	60	10.20	345.8	0.282	3.55	43055	47.69	0.1368	54.25	169.2	8.39×10^{-10}
5	60	9.29	351.9	0.313	3.20	39200	48.13	0.1205	54.25	154.0	8.99×10^{-10}
6	60	8.18	338.4	0.348	2.88	35028	47.84	0.1076	54.25	137.7	9.03×10^{-10}
7	60	6.16	338.8	0.463	2.16	26571	48.33	0.0829	53.00	104.3	9.30×10^{-10}
8	60	7.17	340.2	0.399	2.51	30938	48.45	0.0927	53.00	121.6	8.91×10^{-10}
9	60	8.17	346.0	0.352	2.85	34842	48.14	0.1054	53.00	137.0	9.05×10^{-10}
10	60	8.18	348.0	0.353	2.83	34847	48.37	0.1066	53.00	126.9	9.15×10^{-10}
11	60	9.18	342.6	0.311	3.22	38850	47.47	0.1220	53.00	152.6	9.54×10^{-10}

[1] For an abstract of the article of C. Bach and R. Stückle, see *The Journal*, August, 1913, p. 1444, and *The Engineering Review* (London) April 15, 1914, p. 375.

uring the water of condensation coming from a steam turbine which appeared to be a more exact method than determination by measurement of boiler feedwater in which a source of error is constituted by the determination of the boiler water level. The tests extended to the determination of the fall of pressure in straight pipes, quarter bends and expansion pipes, poppet valves, slide valves and in T-pipes as well as in combinations frequently occurring in actual practice, such, for example, as the piping leading from the upper drum to the main steam piping or from the entrance into the water separator to the nozzles of a turbine.

The piping of 300 mm. (12 in.) inside diameter was first investigated. The data of this test are given in Table 7. Fig. 10 indicates schematically the construction of the piping, all quarter bends being transferred into the horizontal plane. The variation of the specific weight of the steam was effected by means of the throttling valve I. In order to make sure that the throttling did not affect the pressure measurement at point I, a second point of measurement has been established 1450 mm. (57 in.) from the middle of the flange joint. Tests 7 to 11 refer to the stretch from measuring point II to measuring point III. Measuring point III is located 200 mm. (8 in.) in front of the flange joint, at the valve X. The length of the piping from measuring point I to measuring point III is 54.25 m. (178 ft.) and from measuring point II to measuring point III 53.0 m. (174 ft.). Into the stretch measured are built in seven flange joints (steel castings with the pipes rolled in), one T-piece VI, serving as a joint for another pipe and during these tests passed through by the steam without change of direction, and nine quarter bends of different radii and length. The absolute pressure was determined by means of a check spring manometer at point III, the fall of pressure in the stretch measured by a mercury manometer described elsewhere. The average pressure in the piping was determined by these two observations. In column 12 of Table 7 the coefficient of conductance β_e was calculated from the formulae. [The article is not finished.]

ENGINEERING SOCIETIES

AMERICAN INSTITUTE OF MINING ENGINEERS

Bulletin, No. 88, April 1914, New York.

Sound Ingots, Sir Robert Hadfield

Notes on the Plastic Deformation of Steel during Overstrain, Henry M. Howe and Arthur G. Levy

Manganese Steel, with Especial Reference to the Relation of Physical Properties to Microstructure and Critical Ranges, W. S. Potter

Notes on the Utilization of Coke-Oven and Blast-Furnace Gas for Power Purposes, Heinrich J. Freyn (abstracted)

NOTES ON THE UTILIZATION OF COKE-OVEN AND BLAST-FURNACE GAS FOR POWER PURPOSES, Heinrich J. Freyn (30 pp., *cd*). The paper attempts to cover the whole field of utilization of coke-oven gas for power purpose, as well as the surplus gases of a blast furnace. The author distinguishes for the coke-oven gas between the "cost of production" and "value of consumption" of the gas and finds that the intrinsic value of both blast-furnace and coke-oven gas depends greatly on the use factor of the power plant, and at a price of say 12 cents per 1000 cu. ft. for domestic use coke-oven gas would be more valuable as a gas engine fuel if the power plant operates at 80 per cent load factor throughout the year. When there is an unlimited market for electric power and nearly full output of the gas engine station, it would be more profitable to operate gas engines on coke-oven gas than to sell the latter for domestic purposes, provided coke-oven gas could be used in very large gas engine units as satisfactorily as blast-furnace gas, which is as yet not quite the case. Coke-oven gas varies greatly in composition according to the kind of coal carbonized and the time of generation during the process of carbonization, and contains from 50 to 60 per cent hydrogen. Blast-furnace gas requires approximately its own volume of air, while coke-oven gas must be mixed with from 8 to 15 volumes of air for complete combustion. The large percentage of hydrogen causes an extremely rapid flame propagation, making a combustion of a more explosive character than is the case with blast-furnace gas. The compression in coke-oven gas engines must, therefore, be kept lower than is customary for blast-furnace gas engines. But according to thermodynamic law, a lower compression is necessarily followed by a lower thermal efficiency. But it has been found in practice in Germany that the actual heat consumption per b.h.p-hr. of coke-oven gas engines at full load is practically the same as that of blast-furnace gas engines for the same load conditions, which is due mainly to the fact that, for practical considerations, coke-oven gas engines must be operated on very lean gas mixtures. Owing to the snappy action of the gas, coke-oven gas engines are at times quite susceptible to back-firing and premature explosions, and effective cooling of gas cylinders, pistons, piston roads, etc., becomes therefore a very important matter. This, as will be stated later, is apt to lead to troubles of its own. The latest coke-oven gas engines built by Thyssen & Company were installed in Westphalia. Each engine is of the twin-tandem, double-acting four-cycle type, having four gas cylinders 47½ in. in diameter, 51 in. stroke, and develops at 94 r.p.m. about 5000 b.h.p. It is used to drive alternators operated in parallel with a central station in Essen, the parallel operations being beyond criticism. The compression pressure is only 85 lb. and the maximum explosion pressure does not exceed 250 lb. per sq. in. The M. A. N. Company of Nuremberg, Germany, say that they are building units of 6000 b.h.p. capacity in four cylinders. Generally, however, it seems that in Europe about 1100 to 1200 b.h.p. per double-acting gas cylinder is at present the upper limit while in this country the majority of gas engine manufacturers restrict the capacity of coke-oven gas engines to about 700 to 850 b.h.p. per double-acting cylinder.

As regards the fuel it is the presence of sulphur in coke-oven gas in the form of sulphuretted hydrogen and carbon bisulphide which causes all serious trouble. The slightest water leak into the gas cylinder from defective pistons or water-cooled exhaust valves results in serious corrosion of all finished parts, particularly of piston rings, piston roads and metallic packing. This corrosion is caused by sulphuric acid formed by the combination of oxygen and water with sulphur dioxide resulting from the combustion of sulphur in the gas. Several gas engine builders in Germany abandoned on this account the use of water-cooled exhaust valves and substituted solid non-cooled valves. But many prominent manufacturers prefer to use water-cooled Durana metal exhaust valves on account of the high temperature of the exhaust gases. In recent years considerable progress has been made in designing sulphur cleaning plants which eliminate nearly all of the sulphuretted hydrogen but no practicable means

have so far been discovered to separate carbon bisulphide from the gas. Nitric acid formed in the gas cylinders during combustion of the charge has also a corroding effect upon the finished engine parts. This source of danger is, however, minimized if the direct ammonia process is used so that the ammonia is practically eliminated from the gas. At times there is trouble when naphthalene is present; it is deposited by the gas, particularly in cold weather, and easily obstructs the pipe-lines and valves. If benzol is recovered from the gas, no trouble from naphthalene can occur since it is absolutely necessary for an efficient benzol recovery to extract the naphthalene from the gas. Where this is not done, the gas pipes have not infrequently to be steamed out, in order to dissolve the naphthalene.

It has been suggested several times that a mixture of blast-furnace and coke-oven gas be used which might combine the good points of both and at the same time eliminate nearly all objectionable features. With a considerable compression pressure perfectly satisfactory results from the use of such mixtures in gas engines are assured and the heating value of such a mixture would be maintained uniform, if one could commit this task to the action of some automatic device. Where such a mixture is used now, its heating value is controlled by hand, and its composition appears to correspond very nearly to that of producer gas made from coke or anthracite coal.

The author gives a complete detailed calculation showing the final advantage of using a mixture of blast-furnace and coke-oven gas instead of straight blast-furnace gas for power generation in a gas engine plant as well as a calculation showing the comparative advantages of installing a 450-tons or a 350-tons capacity blast furnace, and on the whole comes to the conclusion that the unit cost of making coke-oven gas in a larger coking plant is a good deal less and the total revenues from the utilization of blast-furnace and coke-oven gases are considerably greater with larger than with smaller blast furnaces.

AMERICAN SOCIETY OF CIVIL ENGINEERS

Proceedings, vol. 40, no. 4, April 1914, New York.

The Determination of Safe Yields of Underground Reservoirs of the Closed-Basin Type, Charles H. Lee
Cinder Concrete Floors, Guy B. Waite (abstracted)
Huacal Dam, Sonora, Mexico, H. Hawgood
Reinforced Concrete Docks, Harrison S. Taft (abstracted).

Reinforced Concrete Docks: Foreign and American Structures, Failures, Costs, and General Considerations, Harrison S. Taft (52 pp., *cdg*). While in the United States the construction of reinforced concrete docks is still in a very embryonic state and concrete structures in sea water have not always been successful, it has been used with complete success for more than 50 years in Europe for structure exposed to the action of salt water, and English engineers have been building reinforced concrete docks for about 20 years. The present paper contains a brief outline of the reinforced concrete dock problem as developed in Europe and Asia as well as a review of the art as carried on in this country both in sea water and fresh water. It takes up the subject of failures in past uses of cement in sea water in America and brings out the fundamental principles covering the successful use of concrete in structures exposed to salt water and frost action. It discusses also the question of the first cost of reinforced concrete docks as well as the cost of annual repairs. The first cost of the various reinforced concrete dock structures at Port Talbot is stated to have been "no more than if they had been built of wood," but such a statement would not perhaps be true in the United States on account of the large forests in this country. As regards the maintenance costs it is stated that the cold storage wharf at Southampton, England, has cost nothing for maintenance to date, while the widened dock and coal jetties are said to have shown considerable deterioration, due to rust of the steel which was improperly laid in the structure. The only repair charges on the Purfleet coaling jetty, exclusive of the damage done at the time of the collision, are stated to have been but $50 per year, which, based on its cost of $60,000, is less than one-tenth of 1 per cent.

The author then proceeds to review the opinions of foreign dock engineers on the use of concrete in sea water and on the practicability of reinforced concrete docks. Henry Hunter, chief engineer of the Manchester Canal, England, states that "the concrete in the concrete lock building in Eastham is in better condition at the present time than the day it was deposited." William Cleaver has stated that "while the reinforced concrete requires extreme care both in the choice of material and in the supervision of the workmanship, the results justify the extensive adoption of the material for dock work." Francis E. Wentworth-Shields, dock engineer of wide experience with the London & Southwestern Railroad Company, has stated that "if great care is exercised in making and placing concrete, an impermeable material will be obtained, which can withstand the action of salt water." He stated also that under certain circumstances reinforced concrete, when used in marine work, was likely to deteriorate, but did not think it would do so simply from standing in sea water, though in some cases deterioration had taken place at Southampton above low water, it had not done so below low water and during that whole experience at Southampton, sea water did not seem to have produced any chemical or deleterious action on the concrete. It would stand a wonderful amount of shock and bending due to shocks, if a wooden fender were interposed; on the other hand, reinforced concrete would not bear being knocked about by heavy ships and where structure was subjected to severe blows of that sort, it was not easy to find anything better than timber.

The author concludes that while it is true that all American cements are not yet wholly suitable for sea water purposes, successful marine reinforced work can be done here. But in spite of its apparent simplicity on dry land, the use of reinforced concrete in dock work calls for more than mere brawn and muscle. It is a class of construction work especially adapted to the broad knowledge, experience and deep study of the trained engineer in association with an organization well skilled in the handling of concrete in sea water structures.

Cinder Concrete Floors, Guy B. Waite (18 pp., 15 figs, 13 tables). In this paper the manner of using reinforced cinder concrete floor slabs by various cities in the eastern part of the United States is described. Especial attention is called to the arbitrary manner of using this material, and the insistence of continuing this arbitrary use, by New York City, as indicated by the latest building codes. Attention is called to the unit stresses adopted by various cities and to recent data tending to establish unit working stresses from actual tests. The qualifications of this material for the purposes described are discussed, and a comparison with stone

concrete is made. The manner of arbitrary testing is described, and the difference between the conditions of such tests and the actual loadings found in buildings is pointed out. Analysis is made of the arbitrarily approved reinforced cinder concrete floor slabs, showing the stresses which would be imposed on the materials by the maximum approved loads. Cinder concrete is described and tabulations are made for the location of the neutral axis and for the carrying capacities, assuming various unit stresses. The influence of the stresses due to an excess of steel or to an excess of concrete is discussed. Analyses of stresses allowed by such tests indicate that in some cases approvals have been given for dangerous construction; it is pointed out that arbitrary tests can be made which indicate carrying capacities not possible under the conditions actually found in buildings; and it is shown by formulations and tabulations that reinforced cinder concrete may be easily and uniformly designed by adopting working unit stresses, and that several cities have adopted such stresses for this material.

The author believes that in this paper he has amply demonstrated that the only manner in which this material can ever be uniformly used under various conditions is for each locality to adopt unit stresses suited to its own conditions.

ASSOCIATION OF ENGINEERING SOCIETIES

Journal, vol. 52, no. 4, April 1914, St. Louis

THE EFFECT OF SATURATION ON THE STRENGTH OF CONCRETE, J. L. Van Ornum (12 pp., 1 fig.). There appears to be little recorded information concerning the treatment of concrete specimens with regard to moisture conditions during their storage while awaiting the test for strength. It is, however, of great importance to specify and standardize the moisture treatment of specimens intended for testing. Since similar conditions act on the specimens as they act on the finished structures, it will affect their strength considerably, and therefore should be considered in specifying the proper unit stresses. This factor is of particular importance, as variations in strength, amounting perhaps to as high as 50 per cent above or below a mean value, result from differences in moisture conditions. This question of the effect of saturation on the strength of concrete has been investigated in the Washington University Testing Laboratory, especially with respect to the effect on the compressive strength of concrete produced by varying systematically the relative length of time of exposure in air and in water. The test specimens were cylindrical, 8 in. in diameter and 16 in. high. The materials were: a standard brand of Portland cement which fulfilled thoroughly all the requirements of the standard specifications; a clean sand of good quality, weighing about 110 lb. per cu. ft. when dry, and having 36 per cent voids; and a washed river gravel of the same weight, varying in diameter from quite small up to 1½ in., and having 33 per cent voids. The proportions were the usual 1:2:4, by volume; the mixing was done throughly by hand; and the quantity of water used was such as to give a moderately wet consistency, which allowed a thorough compacting by stirring with an iron rod and a slight tamping. All details of fabrication, curing, and testing were planned so as to secure such complete uniformity as is practicable to obtain in all regards except the one for which the controlled variation formed the particular purpose of the experimental study.

The cylinders were removed from the molds when two days old, and were tested at an age of six weeks. The intervening 40 days constituted the period in which the duration of their immersion in water was varied systematically from nothing to the full time. The average results of the 240 tests thus made are plotted in the diagram, Fig. 11, in which the abscissae represent that number of days (after the two days in the molds and the time of exposure to air) during which each set of specimens was placed in water before crushing them; and the ordinates give the percentage of strength which each set of immersed cylinders (standing in water for the indicated number of days) was found to have, taking the compressive strength of the dry specimens from the same mix as 100 per cent. Thus, at the extreme left is represented the basis of comparison, or those which were not immersed at all; those specimens which were cured

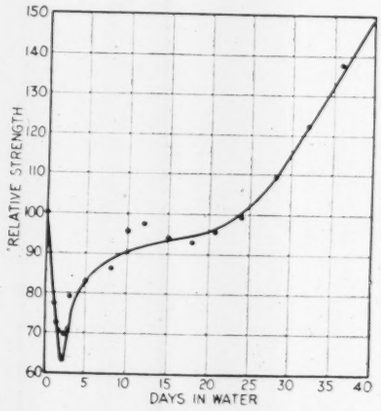


FIG. 11 RELATION BETWEEN SATURATION AND STRENGTH OF CONCRETE

in air of ordinary humidity for 32 days and then immersed for eight days are shown by the black circle to be 86 per cent as strong as the air-cured concrete; those in air for 12 days, and therefore finally cured in water for 28 days, have gained 9 per cent in strength; and those submerged for the entire 40 days exhibited an average compressive strength fully 50 per cent greater than that of the air-cured specimens.

An average curve for the plotted points has been drawn as a full line, showing the systematic increase in strength as the time of submergence is lengthened beyond two days; but there exists the significant fact that specimens, of the dimensions used, decrease rapidly in strength when stored in air for 38 days (or more) and then placed in water for the remaining two days (or less). This particular feature of the rapid loss of strength on first exposure to water, and the active but slower recovery of strength as soaking continued, required a multiplication of tests to determine satisfactorily the locus of the curve in this region; and consequently more than half of the experiments were concentrated in this descending and the adjacent rising portion of the plot.

CANADIAN RAILWAY CLUB

Vol. 13, no. 1, January 1914, Montreal

Cast-Iron Wheel Records, H. H. Vaughan (abstracted)
Cleavage and Crystallization, Griffin (abstracted)

CAST-IRON WHEEL RECORDS, H. H. Vaughan. 27 pp., 14 figs. *ds*). The problem of devising a correct method of keeping records of cast wheels used on a railroad is by no means

simple. Practically all railroads have abandoned any form of record which follows the history of each individual wheel. On some railroads a figure for the average life of wheels is obtained by dividing the number in service by the number removed per year, but this figure is not of much value, as it depends more on the rate at which the number of wheels in service increase than on the actual life of the wheels removed. At the same time the figure showing the life of the actual wheels removed can be obtained with considerable accuracy and with simple reports and records. But while the average life of wheels removed affords valuable information over a period of years, it does not enable the result of any variation in the quality or service of the wheel to be detected until considerable time has elapsed, and then only in a general manner. When the wheel foundry methods of the Canadian Pacific Railway were revised in 1908, it became desirable to introduce some system by which it could be determined whether or not better service results were being obtained without complications of the old individual records. This was accomplished in a satisfactory and simple manner by comparing each year's make of wheels, of the same weight and manufacture, with the number removed for various classes of defect in each year of their life. The information needed to do this was: make of wheel, weight, date cast, maker and cause of removal, items that were likely to be reported accurately, and those required for a record of any kind. As the number of wheels of any group cast in each year was known, the number removed in each year's life for each cause might be expressed as a percentage of the number made, and this percentage might be compared year by year to determine the comparative service obtained from the different wheels.

The author analyzed in considerable detail the records obtained in this way on the Canadian Pacific Railway, and then proceeded to describe the revision of the Canadian Pacific foundry methods in 1908, and results obtained since that date. In order to secure good wheels he considered the inspection which would detect those wheels, which for some reason departed from the accepted quality as one of the most important factors. It should be remembered that out of the ordinary lot of wheels 60 per cent will run through their life and be removed without any defect that reduces the life of the wheel, and better practice or improved inspection are really for the purpose of getting the other 40 per cent out of the way. As regards mixtures, the author states that it is a question to what extent charcoal iron is better than coke iron after being melted in a cupola heated by coke. A chilled wheel has only one serious point of weakness, the danger of broken flanges, and even that appears to have been greatly reduced since 1908 by the use of reinforced flanges, careful manufacture, good inspection and a rather hard wheel.

Cleavage and Crystallization, P. H. Griffin (2½ pp. *p*). Cleavage and crystallization are two of the fundamental factors in the manufacture and use of all articles of steel and iron, and are of great importance for a better understanding of all facts connected with the use of chilled wheels. A rapid and excessive heating of tread and flange by friction of brake shoes and their sudden cooling in wet and wintry weather readily accounts for what is known in railroad parlance as cleavages or cracks. Cleavage is the parting of a crystalline structure in certain lines, notably along the intercrystalline junctions. There are also cleavage lines which form without much regard for the intercrystalline junction lines; and it is to them, in the chilled surface of car wheels, that cracks are due. When the metal is of poor quality and high in impurities, the latter are thrown out as hot metal "freezes," so that finally, in the case of the chilled part of the tread and flange they lodge in the intercrystalline spaces, with a result that when the metal is heated and at the same time subjected to severe shocks and vibrations, the separation to the crystals of chilled iron becomes inevitable. To remedy this condition, the metal used should not contain excessive proportions of impurities, and not only sulphur, phosphorus, manganese, and the like, should be kept within proper limits, but oxides also. When the metal is fairly "clean" or pure it should be also of a quality that will form a crystalline structure without having excessive "smoothness" of the crystalline face.

INSTITUTION OF MECHANICAL ENGINEERS

Application of Electrical Driving to Existing Rolling Mills, L. Rothera (paper read on April 24, 1914, advance copy C. *dp*). The author discusses the important question of installing electrical drive in existing rolling mills, the best methods of doing it and where the system will pay. He takes up the subject from the point of view of economy of running, improved drive, considerations of space, and greater use of existing plant. As regards the economy of running, apart from the question of the cost of power, he discusses the influence of the layout of the works with particular regard to a plant which grew up gradually, and in which the boiler plant has remained centralized. As a result there would be a large number of long steam pipe lines, all acting the part of condensers and probably a number of them leaking considerably. These conditions will to a large extent hold even in the case of a works where there are several boiler stations, and the quantity of coal used per year in making over pipe-line losses and wastage is a very heavy factor in the year's coal bill. In addition to that in an old works there will be a large number of auxiliary machines driving shears, saws, punching machines, etc., which are working under most uneconomical conditions, being in nearly every case noncondensing and often almost undistinguishable when working, due to the steam leakage taking place around them. With electrical drive, the transmission cables can be put up anywhere out of the way and hardly any losses take place.

The next factor is the class of work done. The steam engine while efficient on steady continuous load, becomes very inefficient on a widely fluctuating load. An electrical drive varies only to the extent of 2 or 3 per cent over a very wide range, say from half-load up to 100 per cent overload. It may, therefore, be generally stated that the greater the fluctuations in the load, the more advantageous the electrical drive appears. As regards the question of *improved drive* the steady uniform turning moment produces a better class of rolled material than a pulsating drive. Another feature very noticeable with the motor drive is the faster working consequent from the fact that with the even turning moment there is not the same tendency for the rolls to fail to grip the metal. Also, due to the overload capacity of the motor being in excess of that of an engine, the drop in speed whilst the metal is passing through the rolls is much less with the electric drive than with the steam drive which results in

a higher average speed of rolling and increased output from the mill. Among other features which are also in favor of the electrical drive, the author mentions one, the importance of which is perhaps only appreciated by those who are acquainted with the electrical drive, which is the ease of determining for every pass the power demanded for rolling. Electrical instruments will show with great exactitude the demand for power at any moment, and it is possible perhaps by varying somewhat the drafting of the rolls in accordance with these readings materially to reduce the energy consumption per ton rolled.

The author discusses also to some extent how the electrical drive may permit the utilization of the space available, and easy installation of increased power where such a thing would have been possible only at very considerable cost in the case of a steam engine.

With regard to the method of application of the drive there are four alternatives which he considers, namely, direct-coupled motor, a motor driving through gearing, through a belt and through ropes. *Direct-coupled drive* may now be had (as is done, for example, for heavy sheet mills) down to very low speeds, such as 32 r.p.m. and in a great many cases the extra additional cost of the slow-speed drive is more than counterbalanced by the gain in efficiency due to the absence of any form of transmission losses between the motor and the mill. The latter may become a heavy item in the yearly expenditure. In the case of gearing for varied conditions of working and when the gears have become somewhat worn, the losses taking place in a single reduction, represent hardly less than 5 per cent of the power being transmitted. With the *rope drive*, while the percentage loss is still a somewhat mooted point, it is probably safe to assume it also at 5 per cent and it must be specially borne in mind that the loss appearing in the ropes remains practically constant whether the ropes are running light or transmitting power, and *the loss can be taken on the normal power which the ropes are designed to transmit.* Belt drive is little used in England for this class of work.

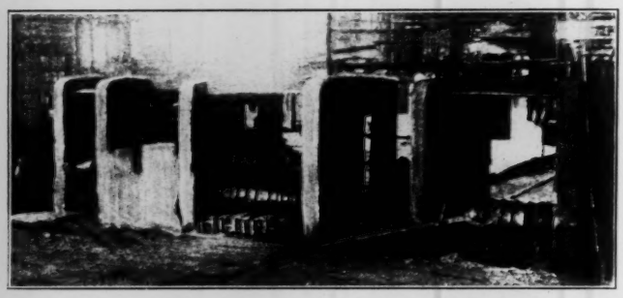


Fig. 12 Direct Coupled Electrical Drive by means of Long Intermediate Spindle

In order to show in a simple form the losses which may occur in one year due to transmission, the author considers a case of sheet mill with a normal power of 600 h.p. on the motor and an average power of 200 h.p. taken by the mill, assuming that the mill is working for 110 hours per week and 50 weeks to the year. The losses in the case of gear drive would be 5 per cent of 200 h.p. or 10 h.p. for 5500 hours, and in the case of rope drive, the losses would be 5 per cent of 600 h.p. or 30 h.p. for the same number of hours, three times as much as in the previous case. Where, however, the question of converting an existing mill has to be considered, the method of drive adopted must be dependent to a very large extent on the layout of the works, as there may be other mills, roof columns or other reasons which may render anyone of the drives, otherwise advisable, impracticable. Then in the conversion of an existing mill must also be considered the question of the length of time for which the mill will have to be shut down in order to make the change. For this reason rope drive is very often adopted since the foundations of the motor and the motor itself can be put down without interfering with the working of the mill, and the mounting of the rope pulley is a matter of quite a short time, perhaps a couple of days. In the case of the direct-coupled drive, the method of avoiding stoppage is shown in Fig. 12, where a long intermediate spindle is introduced between the pinions and the motor, the spindle spanning the space taken up by the existing engine. The change from steam to electric drive in this case does not involve any stoppage of the mill. Sometimes it is possible to put the motor on the side remote from the steam engine and this was done on an electrically-driven reversing mill which has been working now for 5½ years and no trouble whatever has been experienced through its having been found necessary to transmit the drive through the bottom spindle to the pinions. Another advantage of such an arrangement is that the steam engine may be retained for use if necessary.

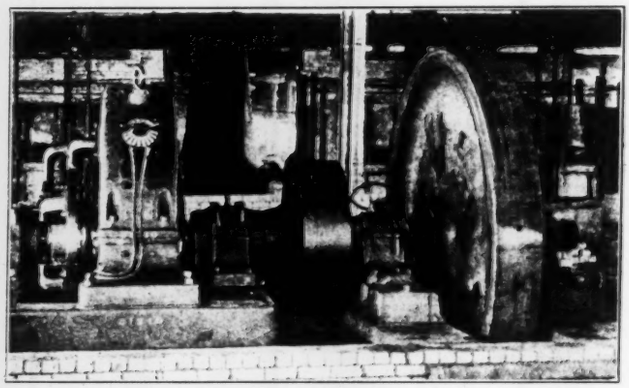


Fig. 13 Continuous Current Motor Coupled to Mill shown in Fig. 12

The weight of the flywheel when the motor drive is applied to a mill is a matter which has to be given serious consideration. It is not a safe method to assume that the existing engine flywheel will be satisfactory for the motor drive. In the case of an engine, the whole of the stored energy in the flywheel is available to pull the metal through the rolls in conjunction with the engine, while the motor has a predetermined drop in speed from no load up to a maximum load which it can safely stand. Assuming, in the latter case, that there is a 20 per cent fall in speed between no load and 100 per cent overload, only 36 per cent of the stored energy is available, after which the motor ceases to drive, leaving only the flywheel stored energy. To some extent this is counteracted by the fact that the permissible overload on the motor will be 100 per cent in excess of the normal power, while in the case of the engine, the overload will not be much more than 25 per cent, but as a rule the motor drive will require a heavier wheel than the engine drive. Providing, however, the maximum peaks are not excessive, a fluctuating load

will not prove harmful to a motor and the weight of the flywheel may be mainly decided from the point of view of cost. Whether to have a large slow-speed, or a smaller, high-speed flywheel is mainly a matter of cost, but the difference is not in many cases very great on account of the fact that the full peak loads of the mill in the latter case have to be transmitted from the motor and flywheel through gearing or ropes, as the case may be, and the size of the gearing and number of ropes will have to be materially increased to withstand this extra strain. In one or two cases the flywheel has been mounted on the motor shaft and the drive through a worm reduction gear on to the mill used. This is an interesting new departure and would appear to be a very satisfactory method if a steady power is demanded, such as for instance in a wire mill or cold roll drive in a tin plate mill where there are no heavy peak loads to be taken by the flywheel, but it is yet to be seen whether it can be made sufficiently strong to last where the full power of the motor and flywheel has to be transmitted through such a gear.

IRON AND STEEL INSTITUTE

Failures of Heavy Boiler Shell Plates. (Presented at the May meeting, reported from an advance paper, 29 pp., 3 figs. in the text and 9 plates. *e*). The author describes a number of cases of failures of heavy boiler shell plates with an indication of the facts revealed by the subsequent investigation of the causes, and concludes that the longitudinal tensile tests, even when taken near the fracture, seldom reveal any abnormal features and transverse tests are more successful; in nearly all the cases dealt with the bend tests were satisfactory, although at first sight it seems somewhat of an anomaly that a piece of plate can be bent through 180 deg. while the whole plate fractures at a very slight angle. The conditions are, however, wholly different: in a bend test, the metal can flow with very little restriction, while in the plate very little lateral flow is possible, so that in a plate the metal is subjected to pure stretch and compression. This fact is of special importance in considering the effect of hammer dressing, as though it is frequently possible to bend a strip of steel after being hammered on the outer surface, it does not therefore follow that hammering a wide plate would be equally innocuous. In general, however, the breakdown is the result of a simultaneous occurrence of several defects, and, for instance, it is not sufficient to say that the plate failed because it was segregated. There is little doubt that there are many more or less segregated plates in boilers, but they have not failed as no adverse conditions were present. A good plan in dealing with a failure is to estimate the percentage value of the different causes producing the fracture with a clear understanding, of course, that such values are only approximate estimates. Hammer dressing may be one of the causes of failure and it is used only because a little hammering frequently saves a good deal of chipping and buffing. It has been pointed out before that severe internal stresses may exist in heavy plates, as their stiffness prevents them from buckling in the manner that thin plates do when the rolls are not true, and this cause may be a factor, perhaps the principal one, in producing failures. In addition to the rolls being actually untrue or having become so when hot, there is also the risk of internal stresses being set up through the plate being subjected to rain from a leaky roof, or from having other plates piled on it when hot. The latter must be considered a bad practice in every way as very serious stresses may be caused through plates only partially covering each other, so that one part of the plate is almost cold while the other is still at a red heat, and it is quite conceivable that this might be sufficient to produce failure. Even if the plate is wholly covered by another, it is possible that it may be maintained at a dangerous temperature of 700 deg. cent. (1292 deg. fahr.), thereby producing brittleness by partially converting pearlite into cementite. The only satisfactory way to insure that heavy plates are as free as possible from internal stresses is to anneal them, and even in this there are several pitfalls to be avoided. For example, mild steels containing a fairly high percentage of phosphorus require very much more drastic annealing than those with a small percentage. It is also of great importance that the whole plate should be raised to the same temperature when being annealed and it is not an easy matter to effect with large plates. In most of the plate investigated after failure the chemical composition is not abnormal, sulphur and phosphorus being not in excess 0.06 per cent, but in large plates, where the work done on them is comparatively small, it is necessary for the metal to be exceptionally pure. Phosphorus and sulphur segregate so much that although a certain percentage would be harmless enough if distributed evenly, it may produce failure owing to these segregations. For this reason it is suggested that 0.05 per cent should be the phosphorus limit, especially if there is an appreciable quantity of arsenic present. Phosphorus has also a strong tendency towards turning pearlite into cementite, which occurs also if the plate is heated for some time at the temperature below 700 deg. cent. or 1292 deg. fahr.

The author discusses at length the question of manholes and finally recommends, in order to eliminate the risk of failures, the use, first, of large ingots; second, effective handling (the pyrometer always being used and a record kept of the temperature to which each plate was subjected, as well as the length of time it was in the annealing furnace); third, low phosphorus not to exceed 0.05 per cent or with arsenic 0.06 per cent; fourth, inspection of all parts which require dressing by an independent inspector, and, fifth, occasional transverse tests to be taken from the centers of the ends or sides of the plates corresponding with the longitudinal axis of the ingot.

Some Recent Improvements in Case-Hardening Practice, Henry L. Heathcote. (33 pp., 4 plates. *de*). The author presents his paper in the form of an account of what has been done on improving case-hardening practice at the Rudge-Whitworth Works. The first problem was to find an improved pyrometer which could be used in a plant having a battery of 13 muffles (the Féry instruments were then unknown). This problem was solved by evolving a color pyrometer based, first, on the fact that the spectrum of a red-hot piece of steel is found to elongate at both the red and violet ends and to increase in intensity all along as the temperature rises, and, second, in finding solutions capable of absorbing the rays emitted by red-hot steel and at various temperatures. The solutions chosen were then properly calibrated and this gave finally a convenient pyrometer. The author's opinion is that a pyrometer which indicates its own temperature may convey some idea of the temperature of the work, but will never be the hardener's friend to the same extent as one of the forms of optical pyrometer, which can

be focused on the article itself, such as the one used at the Rudge-Whitworth works.

Next came the question of investigating case-hardening compositions, their mode of action and effect. Experiments extending over a considerable range of compositions have confirmed the following suppositions: (*a*) the depth of case depends chiefly on the temperature the steel attains and the duration of the hot condition; (*b*) the concentration of the carbon in the case depends chiefly on the rate at which the mixture or its products give up carbon to the steel.

The author also noticed considerable influence of gases, possibly nitrogenous, evolving from the mixture on the efficiency of carbonization. He made a number of "exhaustion" tests, that is, tests to determine after how many heats the mixture is exhausted, this being attained when ferrite bands can be seen between the pearlite grains at the periphery. He found that the best mixture on the score of permanence is wood charcoal, impregnated with soda ash. It can be used practically over and over again indefinitely. It is unlikely, however, that the carbonizing power of mixtures is due to nitrogenous compounds or cyanides, since charcoal soaked in a 5 per cent aqueous solution of sodium carbonate and dried, after three heatings contained 0.12 per cent of nitrogen and no cyanide, and still gave a saturated case even after the tenth, eleventh and twelfth heatings. As regards the permeability to heat, he investigated the influence of the size of particles on the rise of temperature (Fig. 14) and found that the effect of size of grain and particularly of dust is quite material, especially upon the duration

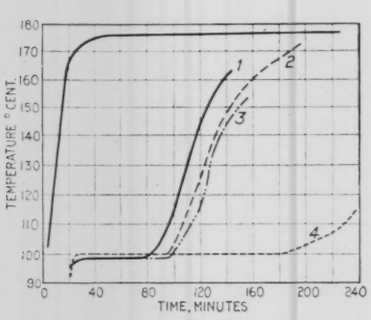


Fig. 14 Influence of Size of Particles on Rise of Temperature in Case Hardening

of the arrest, and that there is an arrest of temperature at the center at about 100 deg. cent. (212 deg. fahr.) while moisture is being driven off. When the same samples were again heated the temperature rose more quickly, with no arrest, the latter fact being due of course to the moisture having been expelled during the previous tests. This makes a mixture, which can be used over and over again, particularly convenient in that the moisture, oil and other volatile constituents should for the most part have been already expelled during the previous heatings.

WESTERN SOCIETY OF ENGINEERS

Journal, vol. 19, no. 4, April 1914, Chicago

City Transportation, Subways and Railroad Terminals, Bion J. Arnold
Wind Loads on Buildings, Albert Smith (abstracted)
The Making of a Technical Journal, E. J. Mehren

Wind Loads on Buildings, Albert Smith (24 pp., 13 figs. and 2 data sheets, *eA*). Last Spring the author carried out tests on roofs of the type of large structures, such as drill-halls and train sheds. The model represented a roof of semi-circular section 6 ft. span and 10 ft. long, covered with tin. It was mounted on walls 5 ft. high. After each set of observations, the roof was lifted and 6 in. of the wall taken off. The walls were made of 2 by 6 lumber, tongued and grooved, the latter making them both comparatively

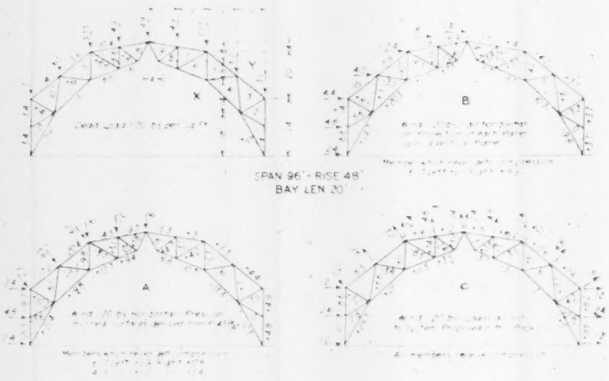


Fig. 15 Stresses in Two Hinged Arch from Three Systems of Wind Loading

tight and somewhat stiff when an end or side was omitted in the course of the tests. The author describes in detail the pressure-registering instruments and the method of taking the observations, as well as the method of calibrating the pitot tubes. He derived a number of pressure diagrams for various winds and also made a number of observations with portions of wall removed. He found that the forces on the building with one side open, while greater than for one of the same height with the side closed, did not exceed the proposed units. With the wind in the other direction, the pressure on the closed wall would be increased by a rarefaction inside the house, and the suctions over the roof would be diminished. Observations on the model with both sides removed show that the stresses for this case are less in amount, and nearly the same in distribution as for the closed house. A comparison of the stresses in a very simple two-hinged arch from three systems of wind loading is shown in Fig. 15. It appears that if the wind loads are as shown by the test described, not only are the stresses assumed to be much too large in most cases, but in two cases they gave tension only in numbers which should be designed for compression. This truss is of exaggerated depth, and in a large truss of ordinary depth the discrepancies would be greater. Such arches are now made entirely of compression sections in most cases, but it would be better to adopt a loading system which makes it impossible to do otherwise. In another illustration the author shows the same comparison for a mill building bent. As in the arch, all members received compression from the proposed loadings, while by the common method three of these members would 14) and found that the effect of size of grain and particu- be designed for tension only. (For the current formula of wind stresses on buildings and its criticism see article on p. 117.)

FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

The man who makes assumptions in engineering must expect to find that he is wrong, and the Engineering Survey of this month presents several illustrations of this fact: the working processes in a suction compressor taking air at an initial pressure above atmospheric are not as they were usually assumed to be; the action of gripping devices on elevators is different from what it was supposed to be; and the same is true to a certain extent with respect to the resistance of locomotives and operation of saturated steam locomotive boilers.

THIS MONTH'S ARTICLES

The article on the operation of suction compressors has been already mentioned above, as well as the investigation of grip devices. In the article on centrifugal pumps built by a German concern is described an interesting type of pump for mine work, particularly adapted to sinking shafts.

The railway engineering section contains an account of tests of a saturated steam twin express locomotive, in which the boiler and engine have been tested first separately, and then together as a unit. In another part of the same section is presented an extensive abstract of a series of Russian tests on the resistance of locomotives and cars while in motion and under various atmospheric conditions (it is the general rule of the Engineering Survey to make more extensive abstracts of articles published in little accessible publications, or languages not commonly known in this country).

A variation in the design of combined Cornwall tubular boilers is described in the Steam Engineering Section, the advantage of the type being its higher coefficient of safety and less necessity for skilled attendance. In the same section is described a rather unusual case of an explosion of a de Laval rotor caused apparently by some internal defect in the material which had not been previously discovered because no overspeed tests of the rotor were made by the manufacturers. R. Schulz shows that it is mainly the presence of oils in imperfectly cleaned water of condensation, used over again as feedwater, that causes corrosion in boilers, while separators for extracting oil from steam, as usually made, are far from being efficient enough to give an absolute guarantee of producing water of condensation safe to use in a boiler. Attention is called to the interesting experimental investigation of what is known as "knocking" in the crank mechanism of reciprocating engines, the main feature of which is that it is *experimentally* determined with a special apparatus which makes it possible to establish the causes of knocking with great completeness. The apparatus also lends itself to several other uses in connection with the investigation of machine parts having a motion different from one along closed continuous curves.

A communication of the German Royal Testing Laboratories at Gross Lichterfelde West describes a new method for the determination of heat conductivity of refractory materials, which avoids the well-known difficulties of the calorimetric method; the apparatus is simple and easily installed.

Richard H. Rice describes the operation of turbo-blowers for blast furnace blowing, and shows, by means of a specially designed apparatus, that, contrary to frequent contentions, the blast from a turbo-blower is actually more steady than that from a reciprocating engine.

From the Journal of the American Society of Naval Engineers are taken articles on the operation and trials of the U. S. Collier *Jupiter*, the construction of which has been described in a paper presented before this Society; and tests on the use of mixed oils in forced-lubrication systems which appear to establish that such a use of oils has no harmful effects. From the same source is also taken an empirical formula for the weight of steam passing through a venturi tube (a modified Rankine formula).

Data upon the new turbine pumps of the St. Louis Water Works, and a formula for capitalizing the investment, are presented in a paper before the Association of Engineering Societies. The Australasian Institute of Mining Engineers has a paper on the requirements of economical winding containing, among other things, an interesting list of safety devices which the author claims to be necessary in a winding engine as "the saving of property in the event of an accident more than compensates for their initial and maintenance costs." The principles of scale construction are summarized from the manuscript of a paper presented before the Eighth Annual Conference of Weights and Measures (very kindly loaned for this purpose by the author, Mr. A. Bousfield).

Professor Horace Judd, in a paper before the Ohio Society of Mechanical, Electrical and Steam Engineers, presents interesting data on the Taylor stoker operating under ordinary conditions.

Owing to lack of space several articles which would otherwise be reported in this issue, have been held until another issue.

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* e perimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

FOREIGN REVIEW

Air Machinery

INFLUENCE OF THE SUCTION PRESSURE OF A COMPRESSOR ON ITS POWER CONSUMPTION AND OUTPUT (*Der Einfluss der Saugspannung eines Kompressors auf dessen Kraftverbrauch und seine Ansaugeleistung*, Hans Wunderlich. *Die Fördertechnik*, vol. 7, no. 9, p. 105, May 1, 1914. 3 pp., 5 figs. *t*). There are still many erroneous ideas about the power consumption of compressors, working on gases having an initial pressure above the atmospheric, and there are even persons who still believe that the compressor working with such gas consumes less power than one handling gas at an initial atmospheric pressure. They do not consider the facts that the suction volume corresponding to various suction

pressures is not constant and that the heat relations in such a compressor are essentially different from those in a compressor which takes its supply at atmospheric pressure. In order to determine the power consumption of such a compressor, the author proceeds in two ways, first determining the theoretical power consumption by means of entropy diagrams, and then graphically.

Theoretical determination of power consumption of the compressor by means of entropy tables. In Fig. 1A *a b* represents the adiabatic curve and *a c* the isothermal. Further, the work of isothermal compression is represented by the area *a c d f* which is geometrically equal to the area *a c g h* representing the *P V* diagram in the present case. It comprises the work of compression and the work delivered at constant pressure. The value corresponding to both of these areas is (see Fig. 1B).

$$L_i = \frac{(S_1 - S_2)\,T_1 . G_s}{A} \text{ m/kg.}$$

If the compression occurs adiabatically, which is nearer to what actually happens, then the area *a b e f* in Fig 1A represents the corresponding work; to this should be added the

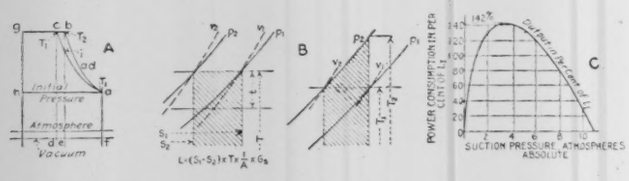


FIG. 1 DIAGRAMS OF THE WORKING OF A COMPRESSOR TAKING GAS AT AN INITIAL PRESSURE ABOVE ATMOSPHERIC

strip *b c d e* representing the heat losses through radiation and conduction, due to the fact that the air or gas goes to the place of consumption without usefully employing the heat which it contained when it left the compressor. The area *a b c d f* represents therefore the total work consumed in adiabatic compression. Such work on the PV diagram being represented by the area *a b g h*, the value corresponding to it is

$$L_a = \frac{C_p (T_2 - T_1) G_s}{A} \text{ m/kg.}$$

In order to obtain the number of horsepower for each case, one must divide the values of L_i and L_a by 75, and this, with mechanical efficiency ϕ, will give the following expressions:

$$N_i = \frac{L_i}{75\phi} \text{ and } N_e = \frac{L_a}{75\phi}$$

In the above formulae and figures, the following notation is used: A, the mechanical equivalent of heat, $\frac{1}{427}$ m/kg; S_1, S_2, entropy; C_p, specific heat at constant pressure; T_1, T_2, absolute temperatures; t_1, t_2, temperatures; G_s, weight of air taken in by the compressor per second; L, work generally; L_i, L_a, work under specific conditions; N_i, indicated horsepower; N_e, effective horsepower; ϕ, mechanical efficiency.

Graphical determination of power consumption. For this purpose one has to plot the PV diagram with the corresponding suction pressures and the required end pressure and evaluate it by means of a planimeter in order to establish thus the average diagram pressure *p m*. From this the work required for operating the compressor can be determined by means of the equation $L = 10{,}000\ F(pm)c = Pc$ and from this the indicated and effective horsepower consumption are derived respectively:

$$N_i = Pc/75 \text{ and } N_e = Pc/75\phi$$

In this equation F is the area of the piston in square meters, *pm* the average diagram pressure in kg. per square meter, *c* piston velocity per second in meters, *P* power on the connecting rod in kg. For air at 16 deg. cent. (60.8 deg. fahr.) and an output of 1 kg. of air taken in per second, the above equation assumes the form $L = 8350\ pm$ m kg.

The author gives two examples of the application of this method of which the first will be reported here. Let the end pressure of an air compressor be 11 atmospheres absolute and be constant, while the suction pressure varies from 1 atmosphere to 2, 3, 4, etc., up to ten atmospheres, increasing by steps of one atmosphere each. The compression is in a single stage and proceeds on the purely adiabatic process, in accordance with the law, $pc^{1.40} = C$, the suction temperature is in all cases 16 deg. cent. or 60.8 deg. fahr., and the weight of air 1.2 kg. per cubic meter (0.74 lb. per cu. ft.). The work theoretically expended by the compressor per second is in accordance with the equation

$$L_a = c_p\ (T_2 - T_1).427.G_s \text{ m kg.,}$$

where G_s is for simplicity's sake assumed, at atmospheric pressure, to be equal to one. The rise of temperature of the air which occurs in adiabatic compression is read off for each case directly from the entropy table. The specific heats vary slightly with the temperature but practically are not affected by high pressures,

$$C_p = 0.2259 + 0.0000394\ T \text{ and } c_v = 0.1574 + 0.0000394\ T$$

The compressor outputs at suction pressures from one to ten atmospheres absolute and final pressure of eleven atmospheres absolute are evaluated as follows: The last column of Table 2 is obtained by making L_a/L_i equal to 100 per cent. This shows the large influence of the suction pressure on the power consumption of a compressor. It appears that it is at its best between three and four atmospheres absolute and from there on rises by about 50 per cent. In Fig. 1C the output curve for this case is plotted and from it the power consumption in percentages of L_a/L_i can be read off directly. The author gives also the ten diagrams corresponding to each of these cases and derives the power consumption for each case from the diagrams. The two methods give practically identical results, but the determination from the entropy table is much easier and simpler. In practice it is quite often important to know which way of compression would prove more economical; for example, if it is necessary to compress a certain amount of air (say for testing purposes) to 225 atmospheres while the compressed air system of the shop has a pressure of only six or seven atmospheres, it is more economical to use a small single stage pump than an expensive two stage compressor. On a larger scale, the same considerations apply to the production of compressed air for mine locomotives. There quite high pressures, around 150 atmospheres, are used, and to produce them four and five stage compressors of about 320 h.p. are required. If the same compressor would receive the air from the compressed air system, i. e., previously compressed to six or seven atmospheres, one could eliminate at least one stage, which would be equivalent to a saving of about 80 h.p. The compressor would become simpler, power smaller and total costs of installation lower.

Hoisting Machinery

INVESTIGATION OF GRIP DEVICES ON ELEVATORS IN ACTUAL OPERATION (*Untersuchungen an Fangvorrichtungen im Betriebe befindlicher Aufzüge*, R. Mades. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 21, p. 827, May 23, 1914. 9 pp., 31 figs. e.1). The present article covers investigations of grip devices on freight and passenger elevators. Most of the investigations made hitherto have been effected with an apparatus showing the retardation of the elevator by means of a spring and weight. In the present instance the process adopted was that of time-path diagrams because it was desired to investigate the motion of the grip wedges, simultaneously with that of the elevator itself. This process led to the formation of new views with regard to the mode of operation of gripping devices. The diagrams were then subjected to a graphical process of estimation. The testing arrangement was such that both cage ropes or each one singly could be instantly released either while at rest or during the downward motion. The releasing device acted so suddenly that in the diagram no distinction could be discovered between the beginning of the theoretical curve of fall and the instant of release. The measuring device con-

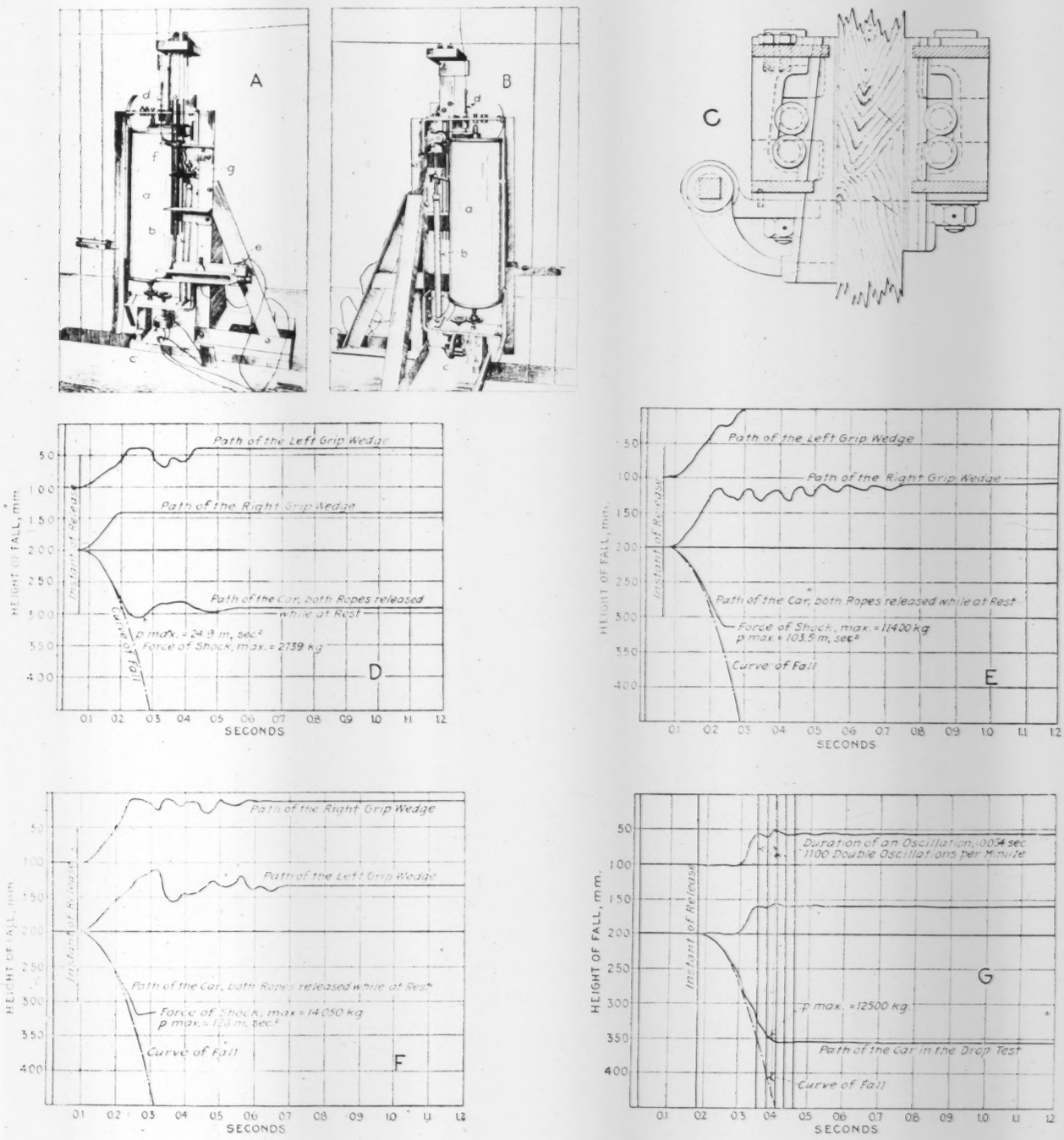


FIG. 2 HOISTING MACHINERY INDICATOR, AND DIAGRAMS OF GRIP DEVICES

sisted of a measuring drum *a*, Figs. 2A and B, 160 mm (6.4 in.) in diameter and 500 mm (19.6 in.) long with a diagram sheet 500 by 500 mm (19.6 x 19.6 in.) area. The drum was at first given an acceleration by means of a powerful spring *b*, and when it reached its highest angular velocity (after a rotation through 40 mm (1.57 in.) measured along the periphery), it was further rotated by a clock device provided with a brake governor *c* in such a manner as to maintain the angular velocity constant. The drum *a* makes one complete revolution and is uncoupled by means of the rope *d* a short time previously to the release of the car. The time of revolution is usually set at one second since, in addition to the gripping process which lasts about 0.2 seconds, there are subsequent phenomena which take up the rest of the time up to one second. This time is measured by means of a calibrated tuning fork *e*, giving 100 double oscillations in one second. The diagram is traced directly on paper. There were also recorded the instant of the release *f* and the motion of both grip wedges *g*. The tests were made with wedges mounted on springs and provided with rolls, Fig. 2C, in such a manner that one rope was released when in the state of rest, first with an empty elevator and then with gradually increasing loads; next, the same test was made during the downward run at normal velocity.

The diagram D shows that the elevator has a free fall up to about 50 mm and from there on begins an irregularity of the curve of fall and consequently some sort of braking. It was established by graphical methods that there is a maximum retardation of 24.9 meters (81.6 ft.) per second per second, when the weight of the elevator proper is 1100 kg (2420 lb.) and no excess load applied. The diagram shows further that after the elevator came to rest, it jumped up 24 mm (say 1 in.) and then after a period of 0.48 seconds came to rest with an average travel of fall of 92 mm (3.62 in.). It was found further that the elevator was thrown upward through the elastic action of the compressed guides and that this upward jump was facilitated through the presence of rolls on the reverse side of the grip wedges. In a a second test the elevator showed a maximum travel of fall 115 mm with a retardation of 103.5 meters (339.48 ft.) per second per second, and a force of 1140 kg (2508 lb.). The elevator was gripped at exactly the same spot as in the first case. The increase of the shock taken up by the two guides appears to be due to the fact that during the first test the guides were strongly compressed at the place of grip and during the second test did not possess the same amount of elasticity. The motions of the grip wedges show that the latter had not come to rest when the elevator was already at rest (compare Fig. 2E). During the third test the maximum retardation rose to 128 m (419.8 ft.) per second per second and the force of shock to 14,050 kg (30,974 lb.). The motions of the grip wedges were still more violent than in the second test while the rise of the force of shock was less than in the second test, which indicates that the guides were compressed nearly to the limit (the gripping was executed always at the same spot, Fig. 2F). Further diagrams show that the shocks and motions of the grip wedges become more and more violent and since they are very irregular in their action, the elevator assumed more and more of a pendular motion and struck against the guides from which it was violently repulsed. If a resonance should occur between the pendular motion of the elevator and the oscillations on the guides, while the motions of the grip wedges should come into synchronism, complicated processes would take place (this may easily happen because the grip wedges are of similar construction and equal weight). The diagram in Fig. 2G shows that the possibility of the motions of the grip wedges being in synchronism, is by no means excluded, and when this happens, the knocks are sometimes so violent that the pencil jumps out of its holder on the drum even though it is held there by a stiff spring.

The author points out that the usual tests do not fully guarantee the safety of operation of elevators as they do not establish the possible weakening of the guides due to the gripping and the loss of friction in the grip wedges due to the roughened face of the wedge being filled up by particles of wood. He recommends therefore a series of tests which would comprise: a release of a single carrying rope, first with no load and then with gradually increasing loads; release from rest of both carrying ropes, first with no load and then with gradually increasing loads; release of a single rope during the downward run at normal velocity, first with no load and then with gradually increasing loads, and a similar release of both ropes. At the same time proper tests should be made to establish at each velocity—whether the governor sets into operation the gripping device and whether it is done in a proper manner. The article contains further tests showing among other things the comparison between grip wedges mounted on springs and working without springs and also the general action of such wedges. In the tests made with passenger elevators, it was also shown that there is a violent jumping of the grips. The author shows the braking follows not, as was hitherto assumed, a parabolic curve, but acts intermittently, in shocks.

Hydraulics

Influence of a Coat of Inert Oil over the Inside of Cement Pipes on the Resistance to the Flow of Water Through the Pipe (*Einfluss des Innenanstrichs von Zementrohren mit Inertol auf die Grösse des Leitungswiderstandes, den Wasser beim Fliessen in Zementrohren findet*, R. Stückle. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 20, p. 796, May 16, 1914. 2 pp., 7 figs). The Paul Lechler Company of Stuttgart, Germany, made quite an extensive series of tests to determine the influence of a paint of inert oil on the flow of liquid in a cement pipe. This was done by comparing the flow of water through a pipe, the surface of which in one series of tests remained rough and in another was covered with a paint of inert oil. The pipe, having a gradient of 231.5 mm. in a length of 15.236 m., was laid for 20 m. (65.6 ft.) and had an average opening diameter of 148 mm. (say 6 in.). It consisted of twenty pieces each one meter long, carefully connected with one another, and the joints filled with cement and thoroughly smoothed. At one end of the cement pipe was added a cast iron pipe about 2 m. (6.5 ft.) long and the same diameter as the cement pipe. At the other end was a connection with a water tank, arranged in such a manner as to permit a constant pressure head, which might vary from one test to another. In all tests the water came out from the piping through a long sweep bend either into a measuring tank or at a free out-flow. In the second series of tests the same conditions were maintained, but the inside of the pipe was covered by a paint of inert oil. The article gives full data of the test. From the results obtained it appears that the

coefficient of resistance, determined from the usual equation given below, decreases for increasing velocities of flow when the latter vary from 0.63 to 1.69 m. per second; but in the case of the pipe covered by a paint of inert oil it is generally smaller than in the rough pipe and decreases more rapidly with increasing velocity of flow, the difference of its value in favor of the oil-painted pipe being 2.5 per cent for a velocity of flow of 0.659 m. per second to 7.1 per cent for a velocity of flow of about 1.69 m. per second. The author gives a diagram where the values of both coefficients of resistance are plotted with water velocities as abscissae and resistances as ordinates. The values of the coefficient of resistance for rough pipes appear to lie in a practically straight line while those for the oil-painted pipe appear to have a considerably greater curvature.

The equation referred to above is as follows:

$$X = h \frac{d}{l} \frac{2g}{c^2}$$

where d = inside diameter of pipe in meters, l = length of pipe in meters, c = velocity of flow of water in the pipe in $m/sec.$, g = 9.81 $m/sec.^2$ and h = loss of head in meters.

Centrifugal Pumps of the Maffei-Schwartzkopff Company in Berlin (*Der Kreiselpumpenbau der Maffei-Schwartzkopff-Werke G. m. p. H., Berlin*, R. Schnabel. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 20, p. 769, May 16, 1914. 10 pp., 53 figs. *d*). The company builds two main types of pumps of the high-pressure type where large heads of delivery have to be handled. The type preferably selected is that with an undivided cylindrical casing: its advantage, especially for operation in mines, consists in the fact that the pump may be dismantled without lifting the casing from the plate. In the other type, which is used mainly, though not exclusively, for small delivery heads, the pump is divided into several sections vertically in accordance with the number of stages, the separate parts of the casing being held together by threaded bolts. The shape of the rotor and distributor blades which determine the output of the pump and its efficiency are in their main characteristics the same for both types. The suction standpipe is located at the side of the coupling in order to preserve the accessibility of the automatic balancing device on the pressure side. All parts inside the pump which have to be provided with packing between two spaces of different pressures, such as the rings at the entrance of the wheels, the bushes between stationary and rotating parts and so on, are made of appropriate alloys, which under ordinary circumstances show practically no wear. Special attention was paid to the production of a device for compensating the axial thrust which would work reliably under all conditions, a fundamental requirement for the operation of a high-pressure centrifugal pump. This device consists of a piston which constantly tends to move the shaft in a direction opposite to the axial thrust, and a vertical throttling disk which regulates the pressure of the fluid acting on the piston and in this way takes up, in an entirely automatic way, the forces constantly acting in the direction of the suction side. In addition to that, the outer end of the piston carries another disk for the balancing of the sleeve. This latter device first comes into action when the piston has undergone a large amount of wear and in this case takes up the axial thrust also.

Apart from the sleeve balancing, which, however, seldom comes into action, the two types of pumps differ with respect to the balancing of the axial thrust only by the location of the throttling disk in front or behind the piston, of which the water leak is further used for cooling the bearings. Since there is little pressure behind the piston, it is quite sufficient to use a soft cotton packing for the stuffing box and a similar packing also on the suction side. In order, however, that no air shall pass through the stuffing-boxes, they are connected with a water chamber, the water of which

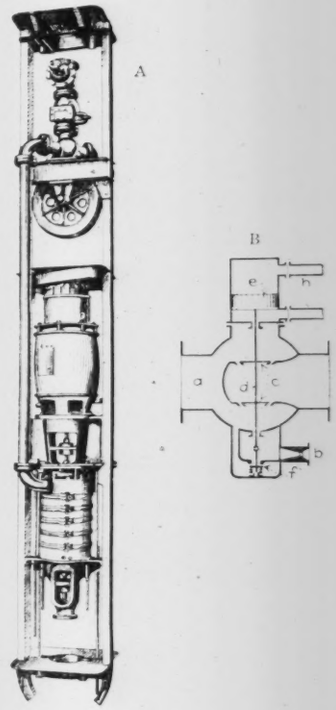


Fig. 3 Maffei-Schwarzkopff Mine Shaft Pump and Pressure-Output Regulator

as a rule is brought in from the first stage of the pressure line.

In considering the two types of pumps, it might be supposed that in the pump with undivided casing, the design of the internal parts would be made more difficult through the possibility of their being affected by handling water with the tendency to form hard deposits, but as a matter of fact no such a thing occurs. The cast iron intermediate parts are covered on the outside with bronze rings, provided with passages into which kerosene is forced from the outside by means of a small hand pump and the casing may have a bronze jacket to protect it against electrolytic action.

The article describes and illustrates various types of pumps driven electrically and by steam turbines. A special type for handling various delivery heads is shown in Fig. 3A and is used for mine work. Since only a part of the cross-section of the mine shaft is available for locating the pump, the latter, together with its motor, are placed vertically in a wrought iron frame provided in the upper part with the rope drum and a rope by means of which it is gradually lowered, as the bottom of the shaft is sunk deeper. The general construction of this pump does not

materially differ from stationary horizontal pumps, but in order to obtain large suction heads and a simple method of water delivery, the suction standpipe is located at the lowest point near the motor on the pressure side. The bearings are finished with particular care and their lubricating oil moves automatically in a closed circuit. The cut-off slide valve is regulated either by hand or by means of a chain and makes it possible to set the pump for a desired amount of delivery.

In order that the pump shall work economically, even at small depths, it is often provided with only part of the stages necessary for the greater depth, the intermediate spaces being filled up with so-called "blind pieces" which, as the depth increases, are gradually replaced by rotors and distributors. The pump body is so constructed that this change may be effected in a short time in the shaft itself. When high-pressure centrifugal pumps are used in mines for pumping against high heads it must be borne in mind that the output varies materially from time to time and adjustment for this may be very simply effected by limiting the upward stroke of the pressure water collector, without having to change the speed of rotation. When the volume of discharge decreases and the pump is working against constant pressure, the collector lifts until it reaches the upper limit. Then the pressure in the piping system rises and thus produces a reduction in the output. If the drawing-off of water ceases entirely, the pump works with cut-off valve closed, but it is not advisable to permit a pump to run for a long time in dead water since the heating of the water might easily injure the internal parts of the pump and it is much better to install a valve governed by the pressure of the water in the collector in such a manner that when no water is drawn off, it would automatically permit enough water to flow into the suction piping or into the well as would prevent any injury to the pump. Such a device is shown in Fig. 3B. It consists of a passage valve casing *a* made of cast iron or steel casting, installed in the pressure piping between the pipe and the collector and provided with an outlet opening *b* for the no-load water. The spindle *d* of a double beat drop valve *c*, carries on top a piston *e* and extends downwards far enough to be able to push off the no-load valve *f*. Two extensions to the pressure water collector permit a small piston not shown in the drawing to move up and down in such a manner that the pressure water may enter either below or above the piston *e*. When the collector reaches its upper level, the pressure water enters through the pipe *h* from above the piston, closes the double beat drop valve and opens the no-load valve. The water delivered by the pump flows off through the throttling nozzle *b*, and the upper consumption decreases to about one half. If pressure water is drawn off and the level in the pressure water collector sinks, the steering piston permits pressure water to enter from below the piston and as a result the double drop valve rises, the no-load valve, under the action of a spring, automatically closes, and the pump begins again to deliver water into the collector (working thus at full output).

Internal-Combustion Engines

Horsepower Formula for Automobile Engines (*Leistungsformel für Automobilmotoren*, A. G. von Loewe. *Der Motorwagen*, vol. 17, no. 13, p. 289, May 10, 1914. 1½ pp. *pm*). The author derives the horsepower formula without introducing the factor p_1 (average piston pressure), and obtains the following expression:

$$N = a \cdot \frac{cn}{2 \times 75 \times 60} \text{ horsepower}$$

where

$$a = \frac{1 - \frac{1}{\varepsilon^{k-1}}}{k-1} \cdot \frac{\pi d^2 s}{4} \cdot \frac{H}{T_0 C_{vm}(L+1)}$$

and N is the theoretical horsepower of the motor; i the number of cylinders; a the work of the motor during its four cycles; n the number of revolutions per minute; d, cylinder bore; s, stroke; $k = c$, ratio of specific heats of the mixture, c_p, at constant pressure, and c_v, at constant volume; ε, compression ratio (ratio of the volume of gas at the beginning to that at the end of the compression stroke); H, heating value of the fuel (kilogram of gasoline); T_0, absolute temperature at the beginning of the compression stroke; C_{vm}, average specific heat of the mixture at constant volume; L, weight of air required for the combustion of 1 kg. of gasoline (all the quantities in standard continental values).

To obtain the effective horsepower, the value of N will have to be multiplied by a coefficient of efficiency η_i, and, since in the derivation of his formula the author started not from the mechanical equivalent of heat, but from the rise of temperature at the instant of explosion, he uses the theoretical thermal coefficient of efficiency $\eta_{th} = 1 - \varepsilon^{1-k}$, and the efficiency of the engine is expressed as $\eta_i = \eta_{qe} \cdot \eta_{th} \cdot \eta_m$, where η_{qe} is the quality factor and η_m mechanical efficiency of the engine.

This leads to the final formula for the effective horsepower:

$$N_e = \left(\frac{1 - \frac{1}{\varepsilon^{k-1}}}{k-1} \right) \cdot \frac{\pi d^2 s}{4} \cdot \frac{H}{T_0 C_{vm}(L+1)} \cdot \frac{i n}{9000} \eta_i$$

$$= B \frac{\pi d^2 s}{4} \cdot \frac{H}{T_0 C_{vm}(L+1)} \cdot \frac{i n}{9000} \cdot \eta_i$$

where $B = \dfrac{1 - \frac{1}{\varepsilon^{k-1}}}{k-1}$

The values of H, T_0, C_{vm}, and L are either given, or can be easily determined by actual measurement; the efficiency η_i may be also assumed to be known; k may be assumed to be known, and the author gives a table for values of B corresponding to certain values of ε, under the assumption that $k = 1.3$.

Assume a four-stroke cycle engine, which has $d = 10.0$; $s = 0.17$; $\varepsilon = 4.8$; $n = 1600$. Then

$$N_e = 1.250 \times 20.4 \times 0.00135 \times 1600 = 55.08 \text{ h.p.}$$

Railway Engines

Tests of a Wet Steam Twin Express Locomotive (*Versuche an einer Nassdampf-Zwillings-Schnellzuglokomotive*, R. Sanzin, *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 22, p. 858, May 30, 1914, 6 pp., 8 figs. *e*). The interest of the tests reported in the present articles lies in the fact that they were first made on the boiler without regard to the engine, next on the engine as such, and finally on the locomotive as a unit, comprising both boiler and engine. The type of locomotives tested was introduced about the year of 1901 and the investigation covers numerous tests on locomotives used for passenger and express traffic on the Southern Railway in Austria.

Table 1 gives the data obtained from the tests of locomotive boilers and in the original article is supplemented by several diagrams. As a basis for the investigation of the processes of combustion and evaporation, there was considered the rate of combustion or the amount of coal burned per unit area of grate per unit of time, which, in kg. per hour per square meter of grate area, corresponds to the amount of fuel in the table indicated by $\frac{B}{R}$. For the determination of the value of $\frac{B}{R}$ only the time was considered during which the throttle was open, as it was found that when the throttle was closed very small amounts of coal were burned, owing to lack of draft. The present investigation was carried on with a grate duty of 200 to 600 kg qm per hour. With smaller amounts of coal burned on the grate the output of the locomotive was so small that it could scarcely be regarded as continuous operation, and while on the other hand a somewhat higher rate of combustion, up to 650 kg qm, could be obtained with expert firing, a maximum grate duty of 500 to 550 kg qm was obtained as an average. The coal was rich in gas, giving a long flame. Its comparatively low heat value (6250 WE) (11,250 B.t.u.) was compensated for by a high rate of combustion. The coefficient of evaporation $\frac{D}{B}$ corresponds to a boiler pressure (gage) of 12.5 atmospheres and temperature of feed water of 10 deg. cent. or 50 deg. fahr. With an average heating value of coal of 6250 WE (11,250 B.t.u.) and a consumption of heat of 655 WE per kg. (1179 B.t.u. per lb.) of steam, a theoretical coefficient of evaporation of 9.55 was obtained, but the actual coefficient of evaporation varied from 8.00 to 5.59 with the amount of coal burned per 1 qm (from 200 to 600), and with the increase of the grate duty, decreased at first rapidly and then more gradually. The variation of the coefficient of evaporation is of great value for the estimation of the fuel, but of course is affected by the kind of firing. The amount of steam $\frac{D}{H}$ generated per 1 qm of heating surface per hour increased with the amount of coal burned per hour but not in a straight line ratio, as $\frac{D}{H}$ remains somewhat behind the growth of $\frac{B}{R}$ owing to the decrease in the coefficient of evaporation, so that, while the amount of coal burned per 1 qm of grate area rose from 200 to 600 kg or increased three-fold, the evaporation per 1 qm of the heating surface increased only from 31.3 to 65.5 kg or 2.09 times. It is, therefore, of advantage to use instead of $\frac{D}{H}$, the value of steam generated per 1 qm of grate area per hour, or $\frac{D}{R}$, since it is not so subject to variations and therefore better permits of comparing various kinds of locomotives.

As regards coal test runs, the author, in addition to the usual measurements of the coal consumed and water evaporated, also measured the rarefaction of air in the smoke box, fire box and ashpan and the temperature of the smoke box gases. The advantages which these simple measurements afforded for the investigation of the process of combustion, proved to be so great that further steps were taken and gases of combustion were analyzed which made it possible to establish a heat balance and gave a clear insight into the processes of combustion.

In the four last columns of Table 1 and in Fig. 4, A is given the distribution of heat in the locomotive boiler for various amounts of coal consumed per unit of grate area, the heat value of the fuel burnt being used as a basis of calculation. During the tests, rarefaction of the air in the smoke box was measured both above and below the spark net as well as in the fire box and ashpan. The average rarefaction of air in the smoke box h and the fire box h_1 are

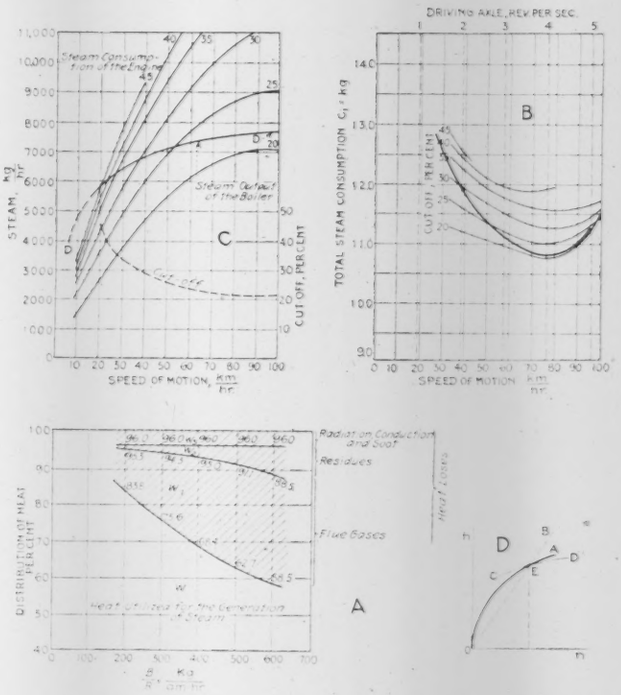


Fig. 4 Heat Distribution and Blast Pipe Operation, Locomotive Boiler

given in Table 1. It appears that h stands in a very simple functional relation to $\frac{B}{R}$ since the values of h obtained in the present test correspond with fair precision to the equation

$$h = 0.00055 \left(\frac{B}{R}\right)^2$$

The following notation is used: for boiler pressure p, for average pressure in the slide-valve chest p_1, pressure at the beginning of admission p_a, at the beginning of expansion p_e, at the beginning of exhaust lead p_e, at the end of the piston stroke p_e, lowest pressure during exhaust p_0, pressure at the beginning of compression p_0, and average effective pressure in the steam cylinder p_i. All the indicator diagrams used in this investigation have been taken with the throttle opened 0.8 of its maximum area, that is $0.8 \times 60 = 48$ qcm. (7.4 sq. in.), as it has been found previously that this opening of the throttle gives the most favorable results and further that no water is carried over into the steam cylinder, while on the other hand the fall of pressure produced thereby between the boiler and the slide-valve chest had no undesirable consequences. The boiler pressure was approximately 12.5 atmospheres, while the

blast pipe was set at its maximum cross section. Since the average useful steam pressure is materially dependent on the boiler pressure, it is worth while to use for its estimation, the ratio $\frac{p_1}{p}$, as this magnitude scarcely undergoes any variation as long as the boiler pressure varies within moderate limits.

The pressure in the steam cylinder during the admission falls off at first slowly and then rapidly. With small admissions the pressure lines during the inflow of steam can be represented with fair approximation by a straight line connecting the pressure p_o with p_a. In this case the initial pressure during admission is p_o and is equal to the average pressure in the slide valve chest p_1. It is especially important to know the value of $\frac{p_o - p_a}{p_o}$ for the design of steam pressure diagrams since it permits not only to establish the exact beginning of the expansion line but also enables to determine the amount of steam actually required during the admission to the steam cylinder.

The influence of the variation of the cross-section of the blast pipe on the back pressure was also investigated in the locomotives under test. The back pressure p_t when the maximum cross-section of the blast pipe of 160 qcm and thirty per cent admission was used amounted, even at five revolutions of the driving axle, to only 0.60 atmospheres, while with a cross-section of the blast pipe of 75 qcm it rose to 1.50 atmospheres with a corresponding material increase in loss of power. During the present test it proved possible on certain runs to test the locomotive with a certain constant cut-off and a speed of run as far as possible unvariable, so that the values for the water consumption after deduction of all losses could be used for the determination of the total steam consumption per indicated horsepower hour (these tests are to be taken with regard to the most usual average cut-off and average speed of rotation). The results of these tests are shown in Fig. 4B. Further the useful steam consumption was determined also from the indicator diagrams, and the difference between these two values for steam consumption shows the steam losses through condensation during admission and through leaks. The curves in Fig. 4C show the steam consumption for various degrees of admission and speed of rotation. If on the same diagram were plotted the curves showing the generation of steam in the boiler, it would give a complete picture of the way the boiler and engine work together.

Finally the total performance of the locomotives was tested, mainly in order to determine its maximum, this being the fact of greatest interest for practical operation. To do this the boiler has to generate the maximum amount of steam that it can do in a continuous run and this steam must be taken care of in the most favorable way by the engine so as to obtain the largest possible amount of indicated power. It has been already explained that the ability to generate steam on the part of the locomotive boiler when a given kind of coal is used depends, practically exclusively, on the draft available. During the run on a given section of the road and for a given amount of steam flowing through a given cross-section of the blast pipe per unit of time, the draft produced depends directly on the number of revolutions of the driving axle; the increase in suction with the increase of speed of rotation of the driving axle is at first rapid, then slower and apparently approaches a certain maximum value, the draft being also for the same amount of steam flowing dependent on the operation of the steering gear, that is beginning of the exhaust lead, shape and diameter of the outflow pipes, etc. The draft under certain conditions produces a certain amount of steam, but may not be able to do it under different conditions. This fact can be well seen when the draft is observed with the same cut-off but variable speed of run. In Fig. D the rarefaction of the air in the smoke box for the same admission but different speeds of rotation is represented by the line OA. In order to maintain this admission, amounts of steam increasing together with the speed of rotation are necessary, and to generate such amounts of steam certain minimum rarefactions of air in the smoke box are necessary and are represented in Fig. 4D by the line OB. The lines OA and OB intersect in point E, which shows that at this speed of rotation the draft required corresponds to the one actually available. For lower speeds of rotation the rarefaction in the smoke box is larger than necessary, while for high speeds it is evidently below that required. These conditions hold for all admissions and there is a certain geometric locus of points of intersection of all required and all actually available rarefactions of air CD, corresponding to the maximum output of the locomotive while in state of continuous operation. From these data on the rarefaction of air in the smoke box and the data contained in Table 1 can be determined the corresponding amounts of coal burned per hour per unit grate area together with the amounts of steam generated in the boiler per hour, and in Fig. 4C the line D shows the total steam generated per hour. This permits to gain a clear insight into the working together of the boiler and steam engine. It shows that with an increase of the speed of rotation the cut-offs one after another intersect the line of steam generation, and this in its turn shows that when such cut-offs are used, the amount of steam generated by the boiler is at first not fully taken care of, then at a certain speed of rotation, the total steam delivered by the boiler is used, and finally at a still greater speed, the boiler is pumped dry. The maximum admissions which are required for the highest outputs are indicated by the points of intersection of the steam consumption and steam generation curves. From these data in Fig. 4C the admissions necessary for obtaining the highest output of the plant can be derived, and it appears that at low speeds of rotation the cut-offs have to be varied rapidly and strongly while at higher speeds only little alteration is required.

Tests (1912-1913) on the Resistance of Passenger Locomotives and Cars on the Russian Railway System (*Opyty* 1912-1913 *g. g. nad saprativleniem passajirskikh paravozoff i vagonoff russkoy seti*, G. V. Lebedeff. ***Bulletin** of the Permanent Committee of the Conferences of Agents of Various Branches of Service on the Russian Railroads* (in Russian), no. 3, March 1914, p. 192. 22 pp., 9 figs. *C.I*). In tests on the resistance of locomotives and cars which are now being made on the Russian railroads, the main basis for determining the power of a locomotive is the traction on the rim of the driving wheel. Actually, however, during test runs it is impossible to measure directly the traction on the rim of the wheel and it must be obtained either by calculation or from the formula:

$$F_k = F_i - W_m,$$

TABLE 1 LOCOMOTIVE BOILER PERFORMANCES

Coal burned per unit of grate area per hour $\frac{B}{R}$ Kg./qm.hr.	Coal burned per hour B Kg./hr.	Steam generated per hour D Kg./hr.	Actual coefficient of evaporation $\frac{D}{B}$	Steam generated per unit area of heating surface per hour $\frac{D}{H}$ Kg./qm.hr.	Steam generated per unit of grate area per hour $\frac{D}{R}$ Kg./qm.hr.	Draft: Smoke box above spark net h_1 (mm. of water)	Draft: Fire box h_2 (mm. of water)	Average temperature of flue gases $T-t$ deg. cent.	Heat distribution, in per cent: Losses through flue gases W_1	Losses through residues W_2	Losses through radiation, conduction and soot W_3	Heat utilized for steam generation W
200	466	3728	8.00	31.3	1600	22	7	190	11.5	0.7	4.0	83.8
250	583	4425	7.59	37.1	1898	34	11	250	15.3	1.1	4.0	79.5
300	699	5047	7.22	42.3	2166	50	16	300	18.7	1.7	4.0	75.6
350	816	5614	6.88	47.1	2409	67	22	350	21.8	2.1	4.0	72.0
400	932	6086	6.53	51.0	2612	90	29	390	24.6	3.0	4.0	68.4
450	1049	6567	6.26	55.1	2818	111	38	415	26.8	3.8	4.0	65.5
500	1165	6978	5.99	58.5	2995	138	48	440	28.4	4.9	4.0	62.7
550	1382	7397	5.77	62.9	3175	166	60	453	29.4	6.1	4.0	60.4
600	1398	7813	5.59	65.5	3354	198	75	460	30.0	7.5	4.0	58.5

where W_m is the resistance of the locomotive as an engine; or else from the formula

$$F_k = F_n + W_v + \frac{P}{g}(1+\gamma)\frac{dV}{dt}$$

where W_v is the resistance of the locomotive as a carriage, P the weight of the locomotive with its tender, γ correction member for the rotating mass, V speed and t time. Since, however, W_m cannot be measured directly, only the second formula can be used for the determination of F_k, but to use it it is necessary to know W_v and $\frac{dV}{dt}$. There is no convenient apparatus for the determination of the acceleration of a train, the apparatus of Desdouits being too rough. Professor Lomonossoff, who is in charge of these tests, has therefore proposed to eliminate from this equation the multiplier of P in the last member, by means of the equation of the motion of cars:

$$Q\frac{1+\gamma}{g}\frac{dV}{dt} = F_n - W_n$$

where Q is the weight of the cars and W_n their resistance. This brings us to the formula of the traction on the rim as

$$F_k = \frac{P+Q}{Q}F_n + P(w_v - w_n)$$

where $w_v = \frac{W_v}{P}$ is the specific resistance of the locomotive as a carriage, and $w_n = \frac{W_n}{Q}$ is the specific resistance of the cars. F_n is determined by means of a dynamometer, while w_v and w_n have to be determined by separate tests.

The resistance of W_v of the locomotive as a carriage can be separated into two parts: The resistance of the locomotive carriage proper W'_v and the frontal resistance W'' of the air medium through which the locomotive has to make a passage for itself. As to the latter it is known that $W'' = \alpha\,\Omega\,V^2$ where Ω is the frontal surface of the locomotive and α is a coefficient determined experimentally and equal, according to the tests of Frank and Eiffel, to 0.006.

The determination of the resistance of a locomotive as a carriage was effected in two ways. The first and simplest was as follows: The train of several locomotives of a given type with the connecting rods taken off, was made up with a dynamometer car in front of the locomotives and connected with them by the dynamometer hook. Several test runs were made. The values of F_n read off on the dynamometer represent the sum of all W_v for all the locomotives *after the speed has become normal.* By dividing these readings by the number of locomotives or their total weight, we obtain the total or specific resistance of a single locomotive at various velocities, the frontal resistance of the air being evaluated in accordance with the formula given above. This method is very simple and convenient when conditions favor its application, but, in order that it should give reliable results, at least two or three locomotives of the given type have to be available, since the dynamometer readings are not reliable for small values of F_n. When only one locomotive of the given type is available, the other method, suggested first by Desdouits, had to be resorted to, namely, letting the locomotive run down an incline.

The theoretical basis of this method is as follows: The equation of the motion of a locomotive with the connecting rods taken off and moving down an incline is

$$\frac{P}{g}(1+\gamma)\frac{dV}{dt} = Pi + W_v$$

where i is the incline in mils. This formula may be converted into

$$\frac{dV}{dt} = \xi(i - w_v)$$

where w_v is the *total specific* resistance of a locomotive as a carriage and $\xi = \frac{2}{1000(1+\gamma)} \cong 120$, from which formula the expression for w_v is $i = \frac{1}{\xi}\frac{dV}{dt}$, which permits the determination of w_v if the incline and acceleration of the motion of the locomotive are known. Now assume that we have a section of the track of a known profile and that the locomotive travels by inertia, having previously received a certain initial velocity. At predetermined points of this section, at equal distances from one another, the time and velocity are recorded. If we assume further that between two points, sufficiently close to one another, the acceleration remains constant, it will be equal to

$$\frac{dV}{dt} = i - \frac{V_2 - V_1}{t_2 - t_1}\cdot 3600$$

if time is expressed in seconds and velocity and acceleration

in kilometers and hours. Substituting this value of the acceleration into the previous equation and assuming a coefficient $\xi = 120$ (this coefficient varies very little for different locomotives), we obtain

$$W_v = i - \frac{V_2 - V_1}{t_2 - t_1} \cdot 30$$

which gives the specific resistance at any desired point of the road. Having performed several tests of running down an incline and referring each time w_v to the average velocity on the given section, we shall obtain a sufficient number of points to draw a smooth curve. The exactness of the results will depend, of course, on the precision of the measurement of time and speed. Initially the tests were performed in the following manner: A section about a mile and a quarter long of uniform, carefully leveled profile ($i = -6$) was selected and along it were placed posts 700 ft. from one another. The test locomotive with the connecting rods taken off was hooked to a dynamometer car, the resistance of which was previously determined. The car was used because it had an electric speed indicator giving instantaneous velocities. Behind the car was a second locomotive, not hooked up to the system, was used to drive the test train up to the first signal post where it was taken off. At the passage in front of each signal post, at the sound of a bell on the loco-

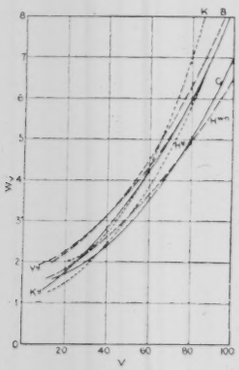


Fig. 5 Locomotive Resistances, Russian Tests

motive, the velocity was read in the dynamometer car from the electric indicator and the time from a stop-watch. It has been, however, found that this method is not suitable because the velocity was not measured with sufficient precision, while the time could be measured with an exactness up to a tenth part of a second. The method was therefore arranged as follows: each section of 700 ft. was divided into two and the time was read on the passage of the intermediary posts. Since at great speeds it was very difficult to notice the passage of each post, 350 ft. distant from its neighbor, only the time of the odd numbered posts were read, the time curves were plotted on a large scale as functions of the distance and the time of the passage of the even numbered posts was determined from these curves, which further permitted the rejection of erroneous observations. The velocity at each n-th post was determined from the formula

$$v_n = \frac{S_{n+1} - S_{n-1}}{t_{n+1} - t_{n-1}}.$$

In this case the dynamometer car is not necessary and the determination of the time can be made with greater precision because the observer does not read the time by the

TABLE 2 OUTPUTS OF THE COMPRESSOR WHEN TAKING AIR AT VARIOUS INITIAL PRESSURES

L_a	Equal to	m/kg per sec.	Per Cent
I	0.246 x 258 x 427 x 1	27000	100
II	0.2435 x 170 x 427 x 2	35500	131
III	0.242 x 125 x 447 x 3	38800	144
IV	0.2385 x 93 x 427 x 4	38000	140
V	0.2385 x 71 x 427 x 5	36200	135
VI	0.2385 x 54 x 427 x 6	33000	122
VII	0.2385 x 40 x 427 x 7	28700	106
VIII	0.2385 x 27 x 427 x 8	22000	81
IX	0.2385 x 17 x 427 x 9	15600	58
X	0.2385 x 8 x 427 x 10	8150	30

bell, but himself sees the signal post and presses the button of the stop-watch on the passage of each, while another man takes down the readings. The great convenience of this method of determining velocities lies in the fact that only one variable, time, has to be observed, which makes the observation easier and naturally raises the reliability of the results. However exact and sensitive a speed indicator may be, when it is used, it is extremely important to have its readings and those of the stop-watch taken simultaneously with the passage of the signal post, and in practice it is very difficult to obtain a perfect synchronization of these three moments. To determine acceleration at velocities above 50 km. per hour, sections of 700 ft. each prove to be too small. The calculations were therefore made by determining the velocity at the first and last sections and by assuming the acceleration on the entire run to be constant.

This assumption appears to be fully legitimate since the points along the curve lay even better than when the acceleration was determined for every 700 ft. Desdouits also made such an assumption.

For every locomotive about fifteen runs down an incline were made in absolutely calm weather and with initial velocities from 5 to 100 kg. per hour. Curve Fig. 5 gives the specific resistance of the locomotives tested. It shows that the character of the curves obtained by dynamometric measurement differs quite materially from those obtained by letting a car down an incline. Since the greatest difference is observed at high velocities it may be assumed that it is mainly due to frontal resistance which in the first case was determined from the formula $\alpha\ \Omega V^2$. It was assumed that the resistance W'_2 is the resistance of the locomotive less its frontal resistance, actually, however, since the locomotive is not fully covered by the car in front of it, it experienced in motion a certain pressure of air on a certain part of its frontal surface. Therefore, in order to obtain the total resistance, it is necessary to have added to the resistance W' a certain magnitude $\alpha\ (\Omega - \Omega')\ V^2$, but if we add $\alpha\ \Omega V^2$, the error is made in exaggerating the resistance. If the locomotive is comparatively low, the error would then be less in the case of a high locomotive. From his investigation, the author comes to the conclusion that for locomotives with a leading four wheel bogie, the equation of specific resistance as a carriage may be taken as

$$W_v = 1.4 + 0.02V + 0.005V^2$$

and for a locomotive with a single leading axle

$$V_v = 1.3 + 0.01V + 0.0005V^2$$

It must be remembered, of course, that this formula gives only the resistance of a locomotive as a carriage. The author

passes then to the consideration of the resistance of a locomotive in motion without steam.

From the equation connecting the tangent and indicated traction forces

$$F_k = F_i - W_m$$

it appears that when the throttle is closed, that is when the indicated force of traction becomes equal to zero, the tangent assumes a certain negative value. This is the resistance of the locomotive as an engine with the throttle closed.

Let us call it W'_m. The total resistance of a locomotive is then the sum of its resistance as a carriage and its resistance as an engine with the throttle closed. Let us call it $W_{p.g}$. Hence

$$W_{p.g} = W'_m + W_z$$

This resistance was also determined by the "incline" method, and the curves obtained were then submitted in several cases to a special method of double graphical differentiation which the author explains in full.

This method is very convenient for freight locomotives where the resistance at high speeds is not required, and for speeds up to 26 miles per hour it gives good results, but for passenger locomotives, where the resistance at high speeds is of principal interest, it is not applicable. The author has determined the resistance of two passenger locomotives with the throttle closed and obtained formulæ of the following kind:

$$W_{p.g} = 2 + 0.06V + 0.0004V^2 + 0.0000013V^3.$$

The cube member is not novel, since Rökl and Desdouits have obtained formulæ of resistance with the throttle closed containing such a member and believed that this member characterizes the resistance determined by the mechanism itself. The author passes then to the resistance of eight wheel passenger cars. A number of dynamometric tests were made in 1912 and 1913 by two students of the St. Petersburg Polytechnical Institute who obtained for the summer time, the following formula of resistance:

$$w_u = 1.2 + 0.01V + 0.0003V^2$$

This formula has been, however, obtained under exceptional conditions with special care for the rolling stock, and it is reasonable to assume that the magnitude of resistance as expressed by this formula is really somewhat below the normal. Professor Lomonossff proposed therefore to use for the average conditions of summer traffic a formula:

$$w_u = 1.5 + 0.2V\frac{V + 100}{1000}$$

The author has derived for the conditions of winter traffic, the following formula, based partly on graphical differentiation and partly on the observation of actual velocities on sections of known profile:

$$w_u = 1.5 + 0.5V\frac{V + 10}{1000}$$

These runs were made in November 1913 at temperatures which varied between — 5 and — 15 deg. R. (20.75 and 2.75 deg. fahr.), often in snow and blizzard, and gives the resistance at average conditions. It is, however, only the normal resistance of the cars, that is, not the initial resistance, but a resistance which becomes established after the train has been in motion for a certain time. In winter the resistance at the starting of a train is considerably higher than after the state of operation becomes normal. This is due mainly to the variation in the temperature of the lubricant, and, naturally, when the locomotive takes from the station a train with the lubricant in the journals frozen, the resistance is comparatively very high. The author proceeds to show how these data on locomotive and car resistance may be used for making up schedule of train runs.

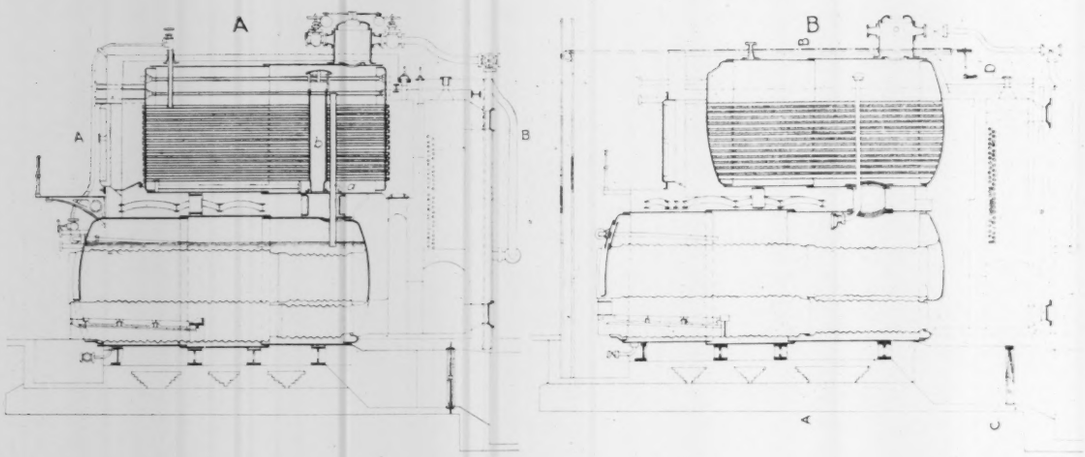
Steam Engineering

A Comparison of the Designs of Two Combined Cornwall Tubular Boilers, with Respect to Safety of Operation (*Ein Vergleich der Konstruktionen zweier combinierter Cornwall-Röhrenkessel auf ihre Betriebssicherkeit*, P. Koch. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 21, p. 255, May 22, 1914, 2 pp., 9 figs. *dc*). The author compares two constructions of combined Cornwall Tubular Boilers. In the original construction, the upper and lower drums were arranged in such a manner as to have a water level in conformance with the German Government regulations, both drums being provided with feed water valves and blow-off cocks. The feeding is usually done into the upper drum wherefrom the water passes to the lower drum through an over-flow pipe *a* (Fig. 6A), while the steam spaces in the two drums are interconnected by means of the pipe *b*. This arrangement is in accordance with German Government regulations but does not guarantee perfect safety of operation and requires absolutely reliable attendance. The fireman, in order to prevent all danger of trouble, has constantly to observe the water level of the lower drum and at the same time attend to the feedwater valve on the upper drum. If then strong drawing-off of steam occurs, it may happen that through the over-flow pipe *a*, not so much water reaches the lower drum as the latter requires to compensate for the amount of steam drawn-off, as a result of which some of the fire tubes become uncovered and, by the action of the heat, annealed and deformed. This may result not only from a sudden drawing-off of steam but may be due also to a mistake of the fireman in observing the water level gages on the upper and lower drums. Further the feeding into the upper drum may also endanger regulation of operation. If for example the water level in the upper drum has gone pretty far down, then until a flow of feedwater through the over-flow pipe *a* into the lower drum occurs, a large amount of water has to be delivered into the boiler by means of the feeding apparatus and in the meanwhile the fire-tubes in the upper part remain uncovered and become deformed, which may lead to all sorts of trouble. On account of all this and several other considerations, it was decided to reconstruct the boiler into the type shown in Fig. 6B, which is really an improved Piedboeuf double boiler with one water space and two steam spaces. It has in all one water level in the upper boiler and one feed to take care of.

Explosion of a Rotor of a Laval Turbine (*Die Explosion des Laufrades einer Lavalturbine*, F. v. Plato. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 21, p. 817, May 23, 1914. 5 pp., 13 figs. *dpe*). On August 6, 1912, in the electrical power house of the Libau (Russia) Steel Works Company, there occurred an explosion of the rotor of a 500 h.p. De Laval steam turbine which was so unusual that the following account is of interest. A thorough investigation followed the accident, the results of which emphasize the necessity for preliminary over-speed tests of all similar parts of high-speed machinery. This turbine was coupled by means of transmission gears to two direct-current generators of 2 x 110 volts each. At no-load on the generator it had a

speed of 10,820 r.p.m., equivalent to a peripheral speed of 445 m. (1460 ft.) per second, the ratio of the transmission being 416:30. The turbine which was in operation on the morning of the explosion was provided later in the day with a new rotor shortly before received from Sweden, because the blades of the old rotor had become considerably worn from the water present in the steam (saturated steam at 8 atmospheres was used). Seven turbines of this construction are used in the plant and as the rotors have to be exchanged about once a year, the engineers had had ample experience in this kind of work. After testing by hand to determine the free run of the rotor, the engine as usual was warmed up and in the afternoon slowly started in the presence of the superintendent of the plant who was standing at the side of the casing. One of the engineers stood near the switch-board and the other was slowly opening the main steam valve and at the same time observing the manometer located behind the regulating valve and later on stated that the steam pressure rose gradually to 3 or 3½ atmospheres and remained stationary at that point; he then fully opened the throttle and approached the turbine in order to open the necessary number of nozzles as soon as the load was thrown on the turbine. The other engineers were cutting in the excitation current and raising the voltage; when the latter reached about twenty volts the explosion occurred, killing the superintendent and another man present and seriously injuring both engineers.

The article describes in detail the various injuries done to the turbine installation and other machinery and passes to the consideration of the probable cause of the accident. It appears that the governor was not destroyed and while there were indications of corrosion in the governor valve, the amount of steam which might pass through it would not be sufficiently large to cause excess speed. No foreign body could get in between the valve disk and seat since there was wire netting at the inlet. Besides, the turbine ran quite well in the morning and if there were material irregularities in the working of the governor, they could hardly have remained entirely unnoticed before; and finally, if the accident were due to excess speed, the most likely thing to happen would be the flying off of the rim of the rotor weakened by the thread made on it. Such cases of rupture of the rim have occurred, but never produce as great damage as in this case. A further supposition is that the accident may have been due to a foreign body getting into the casing, which, however, does not appear probable since in the first instance it would cause a considerable amount of noise and would, therefore, show its presence and second by the centrifugal action of the rotor it would have been thrown out onto the rim and cause its fracture in a different manner from what actually took place. All these and other considerations tended to show that the accident was due not to external causes but to weakness in the material of the rotor. The turbine parts were, therefore, carefully investigated at the Mechanical Laboratories at the St. Petersburg Polytechnic Institute, where it was found that the chemical constitution of the metal did not show any undesirable irregularities, while tests of tensile strength, as shown by curves of radial and tangential stresses, also failed to indicate any serious irregularities. On the other hand a microscopic investigation of the fracture showed that the metal in some places was either partly or roughly crystallized. From the information given by the representative of the concern who built the rotor, it appears that the blades were made from material delivered by an important Swedish metallurgical concern and that the utmost precautions were taken to obtain the best material possible. The pieces when finished are usually tested by the Brinell method and also run for twenty minutes at a speed fifteen per cent above the normal. It appears that in the case of the rotor in question, the Brinell test had been made, but that the test run was omitted. Now the Brinell test indicates only the condition of the surface layers of the metal and gives no information as to possible internal weakness, while very slight errors in the treatment of the metal, especially in its hardening, may lead to the gravest results when the turbine wheel is run at a high speed. It appears, therefore, to be absolutely necessary, when rotors to be run at high speed are supplied, to require properly signed and attested data sheets of a test run of the rotor at a speed 15 to 20 per cent above the normal speed. The great importance of such a test is shown by the tremendous amount of energy stored in a rotor of a De Laval turbine or similar apparatus rotating at high speeds. A disk with its two shaft flanges and bolts as well as the



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The heaviest piece which broke off from the exploded rotor weighed 27 kg. (59.4 lb.). The peripheral speed of the center of gravity of this piece was approximately 200 m. per second (656 ft.), and when it got free from the disk its energy was approximately

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It can be seen from this what a tremendous damage would be done by the sudden liberation of such an amount of energy.

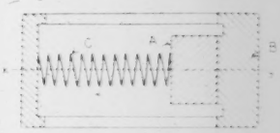
Concerning the Use of Water of Condensation as Boiler Feedwater (*Über Verwendbarkeit von Kondenswasser zum Kesselspeisen*, M. R. Schulz. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 21, p. 257, May 22, 1914. 3 pp., 1 fig. *pe*). A considerable number of com-

Fig. 7 Boiler Corrosion

plaints have been made lately about corrosion in steam boilers, superheaters, steam piping, etc. Such corrosion is generally local and very small at first, but increases later and finally pierces the material by needle-like passages. It may be recognized by observing on the surface of steam pipes and boiler sheets tiny excrescences of 5 to 10 mm (0.2 to 0.4 in.) in diameter, consisting of iron oxide; when they are removed the typical deepening as shown in Fig. 7 may be observed. Chemists have ascribed the origin of such corrosion to many causes, but a long study of the matter brought the author to the conclusion that they do not depend primarily on the quantity of air or of carbon dioxide in the feedwater, but that both of these do accelerate the corrosion if oil is present in the water. Of late a large number of oil separators for steam have been placed on the market, none of which, however, is as effective as it ought to be. One German manufacturer of oil separators offers to place his apparatus on test for three months and take it back without any compensation whatever, if the separator does not deliver the water of condensation "so free from oil as to be fully safe for use as feedwater in steam boilers" and undertakes further to guarantee that the water will contain not more than 0.01525 g per cbm (0.43 grains per cu. ft.) of water. It appears therefore that even during such a test, when the apparatus is perfectly new and assumedly in perfect order, the oil cannot be entirely eliminated from steam. As regards the further guarantee that the water of condensation would not produce corrosion in boilers, three months is far too short a period to enable the user to form any judgment as no corrosion generally occurs within less than one or two years.

Assuming the above apparatus to work as guaranteed on a battery of ten boilers, each having 100 sq. m (1076 sq. ft.) of heating surface and a 25-fold load applied, there will be evaporated per year $10 \times 100 \times 25 \times 24 \times 300$ l (47,540,000 gallons), and in this mass of water will be contained, in accordance with the guarantee, approximately $180{,}000{,}000 \times 0.01525$ g = 2745 kg (6040 lb.) of oil; or, taking about 300 lb. per barrel, there will be about 20 barrels of oil per year distributed through the piping, boilers and superheaters. This is, of course, a theoretical calculation, and actually the case would be still worse as no manufacturer of oil separators would guarantee his apparatus to work up to standard for an entire year and longer. The author, however, does not assert that twenty or more barrels of oil per year would be extracted from the steam plant since part of the oil would be vaporized during the steam generation. Enough will settle in the superheaters, pipes, etc., to produce corrosion.

Taking up different types of plants, the author says that using water of condensation as feedwater is general in sugar plants, where very little is heard of corrosion in boilers, due to the fact that as a rule sugar plants are in operation only eight weeks at one time and at the end of the run the boilers and other appliances are thoroughly cleaned. Further,



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in the sugar factory, in addition to the water of condensation from the exhaust steam of the steam engines is also used the water of condensation obtained from the sugar tanks, which is perfectly free from oil. The custom in such plants, also, is to add soda to the feedwater and thus produce a saponification of any oil particles that may be present. On the other hand, an entirely different aspect is assumed in many factories of other types.

The author quotes a very striking case of a paper manufactory where the boiler plant for more than fifteen years consisted of two double-flue tubular boilers to which were later added several water tube boilers, all fed by ordinary water direct from a well. Usual methods of mud and boiler scale elimination were used and later on water purification by the calcium-soda process was introduced and no corrosion was observed. The plant was then enlarged and new water tube boilers installed. Since the existing feedwater purification plant was not sufficient to supply all the water required, it was decided to collect the water of condensation coming from the exhaust of the engines, pass it through several oil separators located on the exhaust piping and feed the water thus obtained into a battery of water tube boilers. As a result of this arrangement, corrosion developed several years later in the boilers and superheaters, in the feedwater piping and even in the steam piping, making it necessary to shut down the boiler group. The author then enlarged the water purification plant and had all the water of condensation pass through a process of purification, since which no corrosion has been observed, although the plant has been in operation for over a year. It does not appear that the use of cast iron pipes would improve the situation, and in the case of boilers working at a pressure of eighteen atmospheres or more the government regulations in Germany do not allow the use of cast iron.

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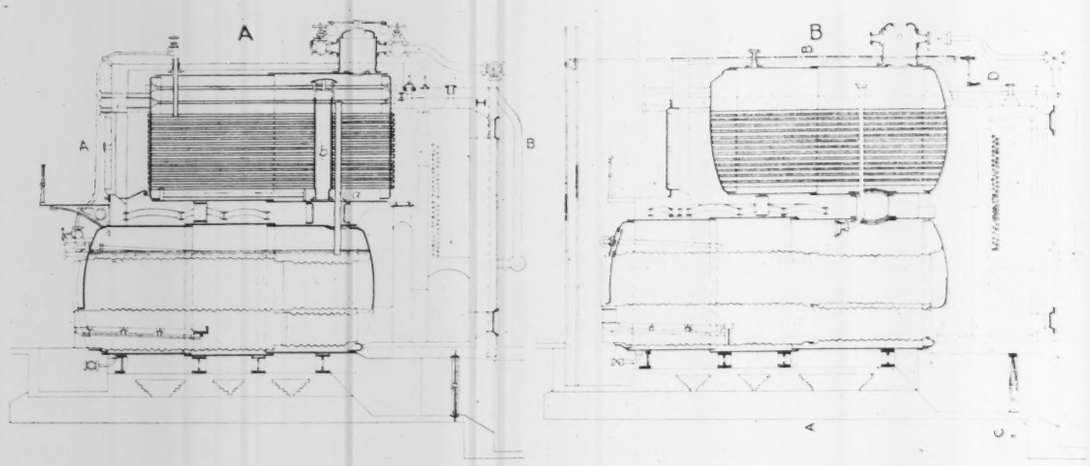

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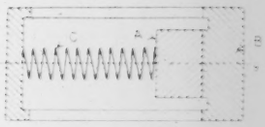

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Experimental Investigation of Variations of Pressure and Shocks in the Crank Mechanism of Reciprocating Engines (*Experimentelle Untersuchung der Druckwechsel und Stösse im Kurbelgetriebe von Kolbenmaschinen*, H. Polster. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 22, p. 867, May 30, 1914. 9 pp., 14 figs. *eA*). The author mentions the difficulties experienced by the designers of steam engines in attempting to increase the speed of revolution because of "knocking" in the crank mechanism due to the resultant of the steam and mass pressures passing from the positive to the negative side during a single revolution. The pressures on the pins which arise as a result of this knocking are very considerable and may exceed the ordinary journal pressures from five to ten times. While many graphical and analytical investigations of the subject have been made, they have not arrived at uniform conclusions.

The experiments of the author were carried out on a Corliss engine at the Laboratory of Mechanics of the Dresden Technical High School. The engine had 450 mm (17.7 in.) stroke, diameter of piston 180 mm (7.0 in.) and was designed for 160 r.p.m. The piston rod with a diameter of 40 mm (1.57 in.) passes through both cylinder covers and is provided with stuffing boxes and hemp packing. The length of the connecting rod is 1000 mm (39.37 in.), the distance of its center of gravity from the cross-head pin is 673 mm (26.3 in.). The reciprocating mass weighs 45.87 kg. (101.1 lb.), the flywheel has an external diameter 1610 mm (63.3 in.) and its moment of inertia is 56.9 mkgsec^2 (412.5 ft.-lb. per sec. per sec.). In designing the experimental arrangement of the apparatus it was required to be able to determine the actually occurring maximum shock, the time of the shock, the instant of pressure variation, and in addition it was desired to be able to investigate separately each of the four shocks corresponding to one revolution of the engine. The shock occurring in the crank pin bearing produced a trembling in the connecting rod. If one assumes at both ends of the rod a sufficiently large amount of play, then the connecting rod at the instant of the shock may be considered as a mass having a free motion of flight and the force producing the shock will communicate to this mass a corresponding acceleration which increases in the same proportion as the force of shock, attains its maximum simultaneously with it, and then begins to decrease also simultaneously with it. If now there be a small mass A as in Fig. 8, which is pressed against a certain body B by means of a weightless spring C and if the entire system be accelerated in the direction of the axis $x - y$ then as the acceleration b increases, the pressure between A and B will decrease more and more and at the instant where b equals the tension of the spring, it will become 0. If b be increased still more, then A will get free from B and the two bodies will come back into contact only after the tension of the spring again exceeds the acceleration (no attention is here paid to oscillatory phenomena).

If now such a device as shown in Fig. 8 be placed on a connecting rod in such a manner that its axial direction be parallel to $x - y$, then with the maximum force of shock P kg, a certain definite maximum acceleration b msec^{-2} of the connecting rod in its axial direction will be produced, and by varying the spring tension F, the apparatus can be adjusted in such a manner that the mass m will be either just in contact with A or in such a position that it could not be brought out of contact with it. Whether this happens, can be determined by insulating A from the spring and connecting A and B with the poles of an electric circuit: at the instant when the current is interrupted in the circuit, one can say the $bm = F$ where b is acceleration of B with respect to A in msec^{-2}, m is the mass of A in kg.m^{-1}sec^2, and F is the tension of the spring C in kg. If further M be the total mass of the connecting rod including the mass of B kg.m^{-1}sec^2, then the force applied to the connecting rod will be $P = Mb = \frac{M}{m} F$. This gives a simple way to measure the force of the shock P which otherwise is not easy to determine, from the tension of the spring F which can be easily measured. The author calls this apparatus "shock meter" and describes fully its actual construction which involves quite a complicated system of electrical connections.

As the lack of space does not permit a complete abstract of the article, only the main results of the investigation are reported here. "The Position of Pressure Variation" cannot act as a criterion for the strength and danger of the shock: the shock at the dead center can be just as innocuous as in the middle of the stroke. The speed of revolution of the engine has a certain influence on the pressure rise per second of the over-pressure line, the latter being proportional to the speed of revolution, yet the speed of revolution does not appear to have any further influence on the force of shock. P is a function of only the "pressure rise" per second of the over-pressure line, dimension of play, and lubrication. With increasing play the strength of the shocks increased and then either decreased, or increased less rapidly, in accordance with the kind of pressure variation, and of lubrication, which is due to the fact that where there is a larger play, the admission of the oil is more effective. The kind of lubrication has a material influence on the force of shocks, poor lubrication producing hard knocking. A very slight oil pressure is required to reduce to a considerable extent the strength of the blows, and higher oil pressures improve the condition still better but not in proportion to the increased oil consumption. The present article is a valuable extension of the former investigations such as those of Stribeck.

Thermodynamics

Investigation of the Heat Conductivity of Refractory Materials (*Untersuchungen über die Wärmeleitfähigkeit feuerfester Baustoffe*. *Stahl und Eisen*, vol. 34, no. 20, p. 832. 3 pp., 2 figs. *e*). The present article, which is a communication from the Royal Laboratory for Testing Material at Berlin-Lichterfelde West, in the first place criticises the methods used for the determination of heat conductivity of refractory structural materials. The process often used hitherto and known as the calorimetric method, consists in heating up from an external source a face A of a plate made of the material investigated, and measuring by means of a water calorimeter the heat coming from the opposite face B of the plate after a normal state of operation has been attained. This process has been very much in favor because it makes it possible to obtain a simple formula for the calculation of heat conductivity, but it has many experimental difficulties and is reliable only when the flow of heat in the calorimeter is absolutely uniform; that

is, when each particle of the area of the heated face A communicates its heat to an equally large particle of the area of the opposite face B of the plate. If this condition is not satisfied, as has been for instance the case in some previous experiments, then the values of conductivity obtained may contain errors as high as 100 to 200 per cent. This condition of a uniform flow of heat is extremely difficult to secure when the calorimeter process is used and if by a special complicated method one manages to satisfy this particular requirement, many other sources of error are likely to arise. The calorimeter method has, therefore, been set aside in the present test and another method briefly described has been used instead.

The test plate was built in in a wall made of stones of the same or similar kind, Fig. 9A. The experimental plate (as well as the surrounding bricks) comes in contact by its face K^1 with the plate P, made up of a highly refractory material. The latter is heated by means of a granular resistance mass M (carbon granules) by means of a current flowing through the electrodes R_0 and R_{10}. Actually, and different from what is shown in Fig. A, the thickness of the wall element in the direction of the X axis (the longi-

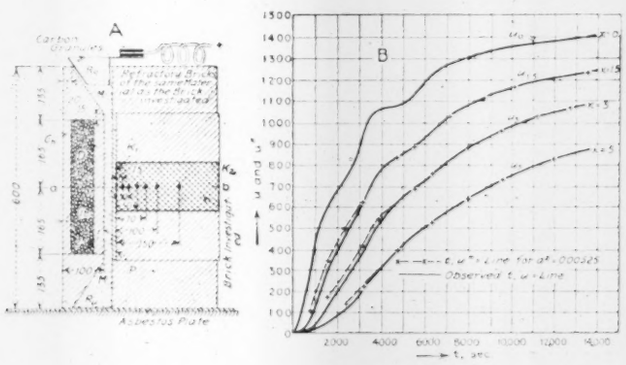

Fig. 9 Arrangement for the Determination of Heat Conductivity of Refractory Materials

tudinal middle line along the experimental brick) was not equal to the length of the brick, but two bricks were placed side by side so as to make the thickness of the wall element equal to two lengths of brick. In the longitudinal axis of the experimental brick are located the soldered-in points of the thermo-elements, as shown in the drawing. The main thermo-elements were thus located at $X = 0$ and $X = 1.5$ cm measured from K_1. All the other connections were used only for the additional control of the tests. After the heating current has been placed in circuit the temperatures u_0 at $X = 0$ and $u_{1.5}$ at $X = 1.5$ cm is read at regular intervals of time by means of the thermo-elements and in this way two curves are obtained with T in seconds as abscissae and the temperatures u_0 or $u_{1.5}$ as ordinates. (Fig. B.) These curves may be called $t - u$ curves; the temperature u is not the actual temperature, but the excess over the temperature of the external air at the point of measurement. If the heat conductivity of a material is called k, its specific heat c and its weight per unit of volume s, then $a^2 = \frac{k}{c.s}$ is the so called temperature coefficient of conductivity which, just as k, is a function of the temperature u. If one assumes that a^2 is constant, that is, independent of temperature, from the shape of the u_0 curve and under an assumption of various values for a^2, one may calculate the position of the $t - u$ curves for various distances X, these lines being called for the sake of distinction $t - u''$ curves. By comparing the calculated $t - u''$ curves with the $t - u$ curves observed from actual experiments, one may draw some conclusions as to a^2 which first shows the specific properties of the material tested and in the second place gives information as to the law of its variation with temperature.

ENGINEERING SOCIETIES

AMERICAN INSTITUTE OF MINING ENGINEERS

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Turbo-Blowers for Blast Furnace Blowing, Richard H. Rice (abstracted)

Data pertaining to Gas Cleaning at the Duquesne Blast Furnaces, A. N. Diehl

Is it Feasible to Make Common Carriers of Natural Gas Transmission Lines, Samuel S. Wyer

The Progress of the Metallurgy of Iron and Steel, Sir Robert Hadfield

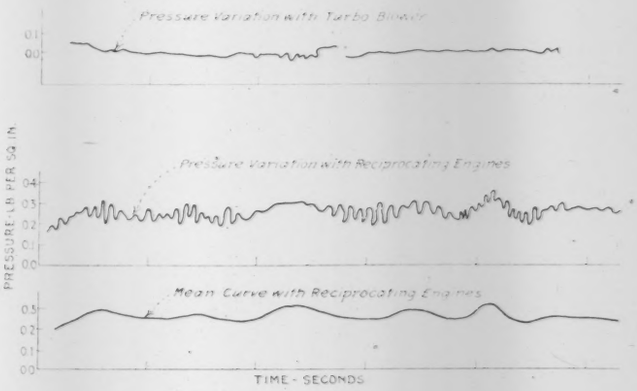


Fig. 10 Pressure Curves of Turbo-Blowers and Blowers Driven by Reciprocating Engines

Turbo-Blowers for Blast Furnace Blowing, Richard H. Rice (22 pp., 9 figs. *dgp*). The paper presents a review of the experience gained and the present state of progress in the design of turbo-blowers for blast furnace blowing. On account of lack of space only certain parts are here abstracted. It has been frequently contended that the blast from the reciprocating engine is just as steady as that from the turbo-blower and that pulsations due to intermittent discharge from air tubs were smoothed by the frictional resistance of blast main and stoves. In order to settle this question a special measuring instrument devoid of inertia was designed, making it possible to obtain a record of the pressure variations in the blast. The record shown in Fig. 10 was made on a furnace working on Southern iron and at the time it was blown with reciprocating engines there were four engines in use, two of which had steam cylinders 84 in. in diameter and air cylinders 84 x 60 in. stroke, while two had steam cylinders 44 in. in diameter and air cylinders 84 x 60 in. stroke and were operated at an average speed of 40 revolutions per minute, giving a total displacement of about 60,000 cu. ft. of air per minute. They were of the vertical long crosshead type equipped with Corliss air inlet valves and modified Reynolds type discharge valves. The curve obtained when operating in this manner apparently consists

of a primary wave and a secondary wave, the first being due to the discharge of the reciprocating cylinders while the secondary waves may be caused by the fluttering of the discharge valves. In contrast with this is shown a comparatively flat curve of pressure variations observed with the turbo-blowers. The article describes also the design of a constant volume governor for centrifugal compressors and gives some data on the performance of reciprocating steam engines, gas blowing engines and turbo-blowers, but comes to the conclusion that the gas consumption of the reciprocating steam blowing engine is so high as compared with that of a turbo-blower that it is not possible with any form of blowing engine to come within reasonable range of the turbo-blower in this respect. The steam practice of blast furnace and steel works is hopelessly behind the times and needs entire revision, but with the introduction of the turbine-driven plant in which modern economical steam practice is applied there is a lower cost of operation, less stoppage and loss of product, and a larger product for the same furnace and one of better quality than by any other prime mover now in use for the purpose.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Journal, vol. 26, no. 2, May 1914. Washington, D. C.

Operation and Trials of the U. S. Fleet Collier "Jupiter," S. M. Robinson (abstracted)
Designing a Foundry for a Navy Yard, F. M. Perkins
The Breguet Ejectair, M. M. Delaporte
Oil Burning, John J. Hyland
The Desirability of Using High Mean Referred Pressures, H. C. Dinger
The Effect of Mixing Oils in Forced-Lubrication Systems, G. S. Bryan (abstracted)
Gearing and the Electric Drive, H. C. Dinger
Empirical Formula for the Weight of Steam Passing through a Venturi Tube, John B. Grumbein (abstracted)

Operation and Trials of the U. S. Fleet Collier "Jupiter," S. M. Robinson (12 pp., 5 figs. *eg*). The article describes operation and trials of the U. S. Fleet Collier Jupiter, equipped with an electric system of transmission between the turbine plant and propellers. The manoeuvering qualities of the electric drive have proved to be highly satisfactory; when the resistances are in, the operation is practically instantaneous and this makes it possible to use the engines to help the rudder. There are several conditions of operation which are peculiar to the electric drive. One is that if operated at all, both motors must go at the same speed; that is to say, it is not possible to go full speed ahead on one of the motors and slow astern on the other. Another peculiarity is that when the ship turns the inboard screw does not slow down but keeps the same speed as the outboard. This results in a slightly larger turning circle at high speed, but apparently the increased pressure on the rudder under these conditions nearly makes up for the effect of the higher speed of the inboard screw. One of the advantages noted in the behavior of the electric drive at sea was the total absence of racing. The governor so effectually prevents this that even with bad pitching there was no change in speed of the motors when coming in or out of the water. Another advantage of the governor is the great accuracy with which any desired number of revolutions can be maintained. The control wheel once set will maintain the same speed within a small fraction of a revolution for an indefinite period of time, regardless of changes in vacuum or steam pressure.

The article gives data of tests in the form of tables and curves. The ship had a water consumption per s.h.p. hour in the 48-hour test of 11.68 lb. (turbine) and in the 24-hour test 12.316 lb. fuel consumption in pounds of coal per hour per s.h.p. 1.662 and 2.5056 respectively, developing 15.9 and 4.48 (?) s.h.p. per square foot of grate surface and 2.82 and 4.43 knots per ton of coal.

The Effect of Mixing Oils in Forced-Lubrication Systems, G. S. Bryan (10 pp., 2 figs. *c*). In the Service of the United States Navy trouble has been experienced in the forced-lubrication systems of main engines and turbines and it has been frequently suggested that this trouble might possibly be due to the mixing of two or more oils in the same system. In order to decide whether or not mixing oils had any harmful effect, a series of tests was undertaken at the Engineering Experiment Station at Annapolis with eight oils, five of which were paraffine base and three asphalt base oil. The test was divided into three general parts: (*a*) tests in oil testing machine, (*b*) chemical examination for condition of refinement and determination of the physical constitution before and after use in above machine, and (*c*) test of oils mixed with steam and water. A special oil testing machine has been constructed to reproduce forced-lubrication conditions. These tests have demonstrated that no harmful effects result from mi ing any or all of the oils tested. It is believed that the eight oils tested are representative enough to cover the field of oils for forced-lubrication and that the conclusions drawn from these tests will apply to all straight mineral oils used in forced-lubrication systems. The article gives also some data on mixtures of oil with steam and water and "separated matter," obtained. This "separated matter" took the form of a thick jelly-like emulsion. The same character of emulsion was formed by bubbling steam through the oil for a few minutes; when the mixture was stirred under 50 lb. steam pressure, the emulsion disappeared and a different kind of "separated matter" made its appearance.

Empirical Formula for the Weight of Steam Passing through a Venturi Tube, John B. Grumbein (2 pp., 1 fig. *et*). The author derives a new formula for the weight of steam passing through a venturi tube, different from the Rankine formula. Fig. 11 gives the results of a series of actual experiments on the venturi meter as compared with the calculated results from the Rankine formula for the flow of steam through orifices. The dotted line corresponds to zero error, the full line to the results obtained by the Rankine formula; these results were 4.9 per cent greater than indicated by the Rankine formula and the experiment indicates that the coefficient 42 employed by Rankine for orifices should be replaced by 40 for the venturi tube. For the venturi meter the author modifies the Rankine formula as follows:

$$W = a_t p_t \, 0.03062 \left(\frac{P_e - p_t}{p_t} \right)^{1/2}$$

where W is pounds per second, a_t area of the throat in square inches, p_t pressure in the throat, pounds per square inch absolute, P_e pressure entering meter, pound per square

inch absolute. The formula has been developed in the laboratories of Sibley College.

ASSOCIATION OF ENGINEERING SOCIETIES

Journal, vol. 52, no. 5, May 1914, St. Louis, Mo.

Timber Conservation and Preservation in the United States, E. L. Powell

New Turbine Pumps of the St. Louis Water Works, L. A. Day (abstracted)

Engineering and Accounting (Discussion).

New Turbine Pumps of the St. Louis Water Works, L. A. Day (13 pp., 4 figs. *de*). The article describes the steam turbines and centrifugal pumps of the St. Louis Water Works. Some time ago when the safe working capacity at the Chain of Rocks Station in St. Louis had been reached, it was decided to replace two 20,000,000 gallon Worthington pumps with centrifugal pumps of greater capacity, namely, two 40,000,000 gallon pumps. Two such pumps of the reciprocating type would have cost approximately $230,000, the duty in feet pounds of work per thousand pounds of steam of the reciprocating type being approximately 150,000,000. Two 40,000,000 gallon turbine centrifugal pumps cost $55,000 with an average duty of 94,000,000, while the maintenance cost in the first case would be about $780 per pump per year and in the second $550. In capitalizing the investment the following formula was derived:

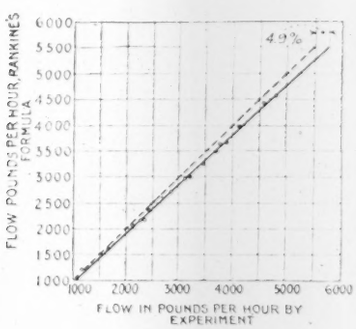


Fig. 11 Curve of Flow of Steam through a Venturi Nozzle

$$\frac{A_x W_x H_x P}{D} + F(i+d) + L + M = C$$

where A is the total number of gallons pumped per year, W weight of a gallon of water, H average total head in feet pumped against, P cost of steam per 1000 lb., D average duty in foot pounds per 1000 lb. of steam, F total investment, i rate of interest on investment, d rate of depreciation, L yearly cost of operating labor, M yearly cost of miscellaneous expenses of operation, C total cost per year. Solving for C with both types of pumps, a difference of $13,000 was obtained in favor of the turbine driven pump, which means that in a little more than four years the centrifugal pumps will have paid for themselves. Needle ice suspended in the river water during the winter and sand throughout the year are additional important reasons for installing centrifugal pumps. On account of these conditions, a contract was given for two De Laval 525 h.p. steam turbine driven centrifugal pumping units each to have a capacity of 42,000,000 gallons in 24 hours working, under a total head including friction in the suction and discharge pipes of 46 ft.; a capacity of 40,000,000 gallons under a total head of 56 ft. and a capacity of 30,000,000 gallons under a total head of 63 ft., the 46 and 63 ft. heads being the minimum and maximum heads at that station, due to the different stages of the river throughout the year.

Each pumping unit consists of two single-stage double-suction 24 in. volute pumps without diffusion vanes and with impellers of the closed type. The double suction impeller practically eliminates end thrust, but a marine thrust bearing is provided at the end of the pump shaft to take care of any thrust, which might occur if for instance something should become lodged in one side of the impeller and prevent the proper filling of the pump on that side. Although manganese bronze proved satisfactory, Government bronze will be used when the impellers require renewal because it can be much better cast than manganese bronze. The pump case is horizontally divided through the center of the main shaft, and when the pump case cover is removed an examination of all working parts can be made without disturbing any of the pipe connections. The only moving parts are the shaft and impeller and the only wearing parts are the wearing rings, bearings and shaft protecting sleeves (Fig. 12). The stuffing boxes contain soft packing with a hollow skeleton ring in the middle of the packing to which clear water under pressure is admitted forming an air tight seal and preventing loss of suction. The shaft in the stuffing box is protected by a bronze sleeve which forms a bearing for the packing and can be easily removed when worn or scored. The shaft proper being thus subject to no wear.

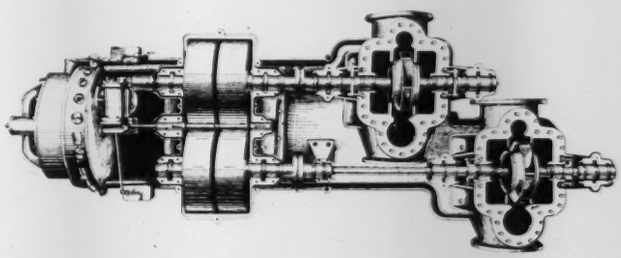


Fig. 12 Bearings of the Turbine Pumps of the St. Louis Water Works

The final tests have given the following results: Head, 53.06 ft.; delivery, 42,900,000; duty, 96,800,000; head, 55.46 ft.; delivery, 30,040,000; duty, 93,800,000. The impellers were changed after installation and the following results obtained: Head, 58.86 ft.; delivery, 38,480,000; duty, 104,100,000; head, 62.15 ft.; delivery, 36,458,333; duty, 101,600,000.

Answering questions in the discussion which followed, the author stated that the best speed at which the pumps should run is to a great extent a matter of calculation and it is likely that as far as the exact speed is concerned each pump would have its own particular characteristic. For instance, the design of the wearing ring would affect the capacity of the pump and the builders themselves have constants which they use and of which they did not inform the purchasers. The speed is not changed with the change of head. The mechanical efficiency of the aggregate will run around ninety-five per cent over all, vacuum being 27 to 28 in.; at full load,

the steam consumption was 15.1 lb.; at one-half load 16.3 and at three-quarters load 16.1 lb.

AUSTRALASIAN INSTITUTE OF MINING ENGINEERS

Proceedings, New Series, no. 13, 1911, Melbourne.

THE REQUIREMENTS OF ECONOMICAL WINDING, J. Armstrong Turnbull (43 pp., 37 figs. *p*). The paper describes the main points for special consideration regarding winding engines used in connection with vertical and inclined shafts. The article is of a practical nature and on account of lack of space only certan few points will be referred to here. Head frames are usually constructed of wood, owing to its supposed cheapness. Wooden head frames, however, require quite a number of extra members; not from a load resisting point of view, but from the standpoint of mechanical construction. As an iron or steel frame can be designed so as practically to reduce redundant members to a very small degree, often the iron or steel frame is the cheaper of the two, besides having a life at least four or six times longer than that of wood. The pit-head pulleys should be at least three quarters the diameter of the winding drum and, preferably, the full diameter of the latter. The losses due to these pulleys are directly proportional to the weight of wheel, its load and diameter of journals multiplied by the revolutions per wind. Hence, these wheels should be large in diameter, and have as small journals as is consistent with strength. It is, however, necessary that the total weight of head pulleys should be kept low, for other reasons than frame strains, viz., in the case of a heavy pulley where the inertia may exceed the rope load, the wheel may continue to revolve after the wind is finished and injure the rope. All winding shafts should be equipped with cages having the following automatic safety appliance: a spring buffer draw-bar, in addition to the usual suspension chains and adjusting screws; safety catches to grip either wooden, iron or pliable slides and automatic stops which cannot be tampered with unless the cage is resting on the shaft catches; overwinding automatic disengaging hook; and a special set of additional catches with adjusting screws placed in the head frame so that the cage or skip when in the overwound position will just press through them and be not more than 6 in. above them when unhooked. The saving of property in the event of an accident more than compensates for their initial and maintenance costs. The author discusses in detail the conditions of balancing on the engines and comes to the conclusion that it is very necessary to keep down the size of winding rope as this causes the largest amount of unbalancing effect on winding engines. He discusses further the principal methods of balancing winding engines, among others the continuous rope systems known as the Koepe and Whiting. It appears, however, that the introduction of any of these systems of winding acts not so much as a means of balancing as a means of reduction of rope abrasion, although these systems especially lend themselves to the suitable application of the tail rope as a balance. The author describes in detail and illustrates the construction of winding engine cylinders and the question of their clearances. The acceleration required in a winding engine is perhaps one of the most severe requirements that steam engines are ever called upon to meet and to ensure the best operating conditions the automatic governor-control cut-off must act within the first two revolutions of the winding drums, and it is most important that there be no hesitation on the governor's part in getting up to speed. The author discusses also in considerable detail the brakes used on winding engine drums as well as the automatic stop motions, and passes on to a brief discussion of electric winding engines.

EIGHTH ANNUAL CONFERENCE OF WEIGHTS AND MEASURES

Washington, D. C., May 1913 (abstracted from manuscript).

SCALE CONSTRUCTION, A. BOUSFIELD. It is of a great advantage to weigh freight cars in motion, but to do this well, the lever system of the scale must be sufficiently heavy to resist, without undue deflection, the effects of the moving loads and the platform must have perfect freedom of motion in both planes and if moved slightly from its normal position, must return promptly to position and balance. The suspension or pendulum system of scale construction appears to be the most accurate that has yet been evolved and for weighing loads is superior to old rigid bearing types. There are three distinct types of levers used in scale construction. The straight line solid lever type is particularly well adapted to track scale work, where great rigidity is an all important feature. The straight line trussed lever type is well adopted to wagon scales where platforms are large and the capacity light. Pipe or torsion levers are adopted to scales which are to be applied to hopper and charging cars. The principal objection to this type of lever is that for heavy capacities the cylindrical portion has to be made very large and heavy, in order to resist the combined bending and torsional strains induced by the loading. If, however, long fulcrums are used and the bending and torsional stresses kept low, rigid and accurate scales can be designed and built with pipe levers. In designing scale levers, it is necessary not only to consider the safe working stresses to which the various materials used may be subjected, but the deflection of the levers under load must also be considered, as one of the sources of error in a scale is the elasticity of the material. Bending and twisting of the lever system tends to change the multiplication and produce alterations in the state of equilibrium. If the size of important members is so reduced as to produce excessive stresses, accuracy will be materially sacrificed when the scale is loaded to full capacity.

Pivots and knife edges may be considered as infinitely small rollers, rolling upon their foundation or bearings. Either a perfectly flat bearing or one whose surface is formed by a large radius is better than a sharp V bearing since with the latter an element of friction is introduced. In some types of special construction the V bearing is a necessary evil. The correct angle for knife edges and pivots has never been very definitely determined. The angle of 90 deg. gives good results for heavy loads, but for scales of light capacities a sharper angle is desirable and for scales up to 150 lb. capacity may be 45 deg. The end to be aimed at in establishing the correct angle for pivot and knife edges is to determine the angle which will enable the pivot to support the greatest load with a minimum wear under all conditions. There is a general agreement among scale designers that the greater the load, the greater should be the angle of pivot or knife edge. The bearing pressure per lineal inch of knife edge has an important bearing on

the enduring accuracy of the mechanism in scales subjected to heavy loads in motion. A load of 5000 lb. per lineal inch will be found sufficiently high. The material almost universally used for knife edges and bearings of large scales is steel. The contact surfaces should be extremely hard while the remainder of the structure should retain toughness and ductility.

In designing levers for scales which are subjected to severe shocks due to the effect of moving loads, an allowance of 100 per cent for impact should be made. It is poor practice to stress the material up to the elastic limit, for when this is done, undue deflection is introduced and this will probably cause inaccuracies when the scale is loaded to full capacity. Before construction work is started, calculations should always be made to determine deflection. In levers for heavy scales it is desirable to have the pivots and knife edges reinforced by projections cast integral with the levers. Where the arc of movement is large, it is desirable to have the pivots placed on the neutral axis of the section to insure an equal distribution of mass about the pivot line. There is nothing of greater importance in the manufacture of scales than the sealing of the levers and beam. Levers of large capacity should be sealed with test weights as heavy as it is practical to handle. It is almost impossible to detect slight discrepancies with light test weights. The notching and marking of the beam is an operation of precision and it is almost impossible to manufacture a machine of sufficient accuracy to do the work without its finally being sealed by a skilled workman.

In testing grain hopper scales of large capacity, such as 2000 bushels, the following method of procedure will give good results: Suspend a temporary framework from the scale platform framing and place 2000 lb. of test weights on each corner successively, testing the beam after each corner has been loaded. When the loading of the last corner has been completed, a load of 8000 lb. of test weights will be placed upon the scale. Then run grain into the hopper until the full capacity has been reached. Rebalance the scale and remove the weights from each corner separately, checking each corner respectively as it is unloaded. Grain hopper scales work under almost ideal conditions since the loads are gradually and steadily applied and removed.

What is probably the largest and heaviest track scale in the world has been recently constructed for the Norfolk and Western Railroad. This scale is 68 ft. long and made in four sections. 5 ft. 6 in. protective overlap is used at each end giving a 57-ft. weighing rail. The main lever stands are placed directly upon concrete foundation and all pocketing of piers is eliminated. The scale is built on 0.75 per cent grade obtained by the use of grade blocks placed under the main girders, the latter being designed as a box chord, and made in three sections so as to eliminate the objectionable upward reaction of the extreme ends. The main levers are cast steel with the load and fulcrum pivots 15 in. long and with the tip pivots 7 in. long. The multiplication of the lever system is 24 at the tip of the extension lever, 200 at the tip of the fifth lever and a multiple of 400 at the butt of the weighing beam. The main bearings are of the suspension type, arranged so as to give perfect freedom and also retain perfect alignment with the pivot edges at all times and without movement of the lever system. The main suspension links, the cross-bars and rockers are of cast steel. The maximum stress allowed in the members under an assumed load of 100 tons is 6000 lb. per square inch in cast steel, 2000 lb. in cast iron, 8000 lb. in structural steel, all three in tension. These scales have been designed for weighing in motion some especially heavy coal cars which have recently been designed by the Norfolk and Western Railroad.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS

Journal, vol. 6, no. 2, 1914. Columbus, O.

The Taylor Stoker Operating under Average Conditions, Horace Judd (abstracted)
Steam Boilers, Their Construction and Inspection, H. A. Baumhart
Centrifugal Boiler Feed Pumps, Edward S. Adams
Uniflow Steam Engine, James H. Debes

THE TAYLOR STOKER OPERATING UNDER AVERAGE CONDITIONS, Horace Judd (paper no. 192, 23 pp., 6 figs. *e.1*). Such stoker trials as have been reported have for the most part been conducted under favorable conditions with boilers and furnaces often of unusually large size and operated under expert guidance. There has frequently been a query among power plant men, however, as to whether the stoker in units of moderate size and tended by the average fireman would give the same favorable showing. The author (assistant professor of experimental engineering in the Ohio State University) during the past year has had an opportunity to make a series of evaporative tests with ordinary attendance at the boilers, and the boiler equipment working under usual commercial conditions. Six of the boiler trials were conducted in March 1913 on a 250 h.p. Babcock & Wilcox boiler of the cross drum type, forming the boiler equipment at the Troy Laundering Company, Columbus, Ohio, and three trials were made on a 300 h.p. Flanner boiler of the same type at the Power Plant of the Ohio State University, Columbus, Ohio. The boilers at both places were equipped with three retort Taylor stokers. The coals in the trials at the laundry were soft coal from West Virginia, Hocking and Pittsburg. The flue gases were passed to a Greene fuel economizer of the usual manifold construction but of unusually large size to give a large storage capacity of hot water for laundry use. At the laundry 10 hours is the average length of time during which the steam supply is needed and this was taken as the duration of the trial with readings every fifteen minutes and flue gas analyzed every half hour from a continual drawn sample. The results obtained from the trials of the laundry indicate on the whole a satisfactory performance for a boiler equipment of the smaller size unit when operated under overload conditions with the ordinary care of the average fireman. The stoker is easily and rapidly cleaned if the clinkers are not allowed to collect to such an extent as to prevent the proper and ultimate mixtures of air with the fuel. The ease with which the dumping process is managed depends largely upon the clinkering properties of the coal. For dump periods ranging from two to three hours, the percentage of unburned coal passing into the ash-pit averaged 4.36 per cent in seven trials. With one hour dump periods, the average unburned coal loss was 9 per cent, showing that the unburned coal loss varied about inversely as the length of the dump interval. It appears that sulphur gave the most trouble from clinkering and in addition sometimes produced very unpleasant fumes. The coal feed is uniform and positive and under

control through the speed regulator on the fan engine. For the different kinds of coal used, the average rates of combustion are given in Table 3. Close air regulation is also possible. During the tests at the laundry, owing to the extremely variable load, the draft over the fire showed a wide instantaneous variation ranging from a pressure slightly above zero to as much as 0.05 suction, though the average results were fairly uniform. The smoke observations were taken with a Ringelmann smoke chart at the heaviest load period during each day's run and showed about the same degree of density for each day. The overload capacity and efficiency is shown in Table 4 which contains the average results for the combined boiler, furnace and grate efficiencies at overload capacities for the nine trials. The trials showing the lowest efficiencies were those when Pittsburg No. 8 coal was used. This coal gave the most trouble in clinkering and also seemed to be a higher coking coal than the other two kinds used. The extreme fluctuation in the load of the laundry made it difficult to regulate the thickness of the fire and this fact emphasizes the need of maintaining a boiler test for at least ten hours unless the load should remain fairly uniform. These results do not give the high efficiencies obtained in trials where the load is carefully regulated, flue gas conditions watched and the combustion adjusted so as to reduce the furnace losses to a minimum. But even in these tests made as far as possible under average operating conditions, it appears that a fairly high overall efficiency for the Taylor type of stoker is within reach of the average fireman. The factors chiefly controlling the efficiency of a Taylor stoker at overload capacity appear to be: the size of unit, per cent of overload, character of coal, the use of indicating boiler room appliances, and the intelligence of the fireman, the latter being without doubt the factor of most importance.

TABLE 3 AVERAGE RATES OF COMBUSTION FOR DIFFERENT COALS

Trial No.	Kind of Coal	Lb. per retort per rev.	Rev. of stoker per hr.	Coal per hr. per sq. ft. grate	Coal per hr. per boiler h.p.
1	W. Va. Splint	15.0	36.0	39.3	3.78
2	W. Va. Splint	16.1	32.8	38.4	3.72
3	Hocking	14.8	36.3	39.0	4.31
4	Hocking	15.8	41.0	47.5	4.73
5	Pitts. No. 8	15.9	38.4	44.5	4.19
6	Pitts. No. 8	15.9	36.8	42.8	4.21
7	W. Va., Fairmont Region	15.8	38.5	35.6	4.06
8	W. Va., Fairmont Region	16.6	41.7	46.0	3.96
9	W. Va., Thacker Coal F'ds., wash.	17.3	51.8	56.2	4.36

TABLE 4 OVERLOAD CAPACITY AND EFFICIENCY

Trial No.	Per Cent Rating	Equiv. Evap. per lb. actual coal	Equiv. Evap. per lb. comb. burned	Efficiency boiler, grate and furnace	Coal per hr. per boiler h.p.	B.t.u. actual coal	Radiation, etc.
7	126	8.49	10.75	67.6	4.06	12184	12.78
3	149	8.03	10.97	69.9	4.31	11164	5.65
4	165	7.31	10.17	67.1	4.73	10570	8.39
6	167	8.24	10.09	63.5	4.21	12582	12.93
2	171	9.26	11.86	72.5	3.72	12375	1.25
1	172	9.15	11.02	69.9	3.78	12697	7.19
5	176	8.25	10.17	66.3	4.19	12067	9.75
8	167	8.71	....	65.8	3.96	12830	12.48
9	186	7.96	10.11	59.0	4.34	13120	15.82
					av 4.15		

FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

In the first section, on Fuels and Firing, will be found articles on a new type of firedoor designed by the Vulcan Shipyards in Germany, as well as a rather peculiar arrangement for regulating the draft in a chimney or stack by means of a wind wheel driven by the upward current in the stack. In the next article are described several types of grates developed in Russia, mainly for use with anthracite fuel, and a new process for manufacturing peat, brought out in the same country, and based on a rather interesting observation that the moisture contained in certain kinds of peat can be easily driven out by mechanical means, but with other kinds this cannot be done. A good fuel can be produced by mixing the two kinds of peat.

Data of tests on high-speed hydraulic forging presses, and description of a valve used for regulating the hydraulic pressure in this kind of machinery, are of interest in view of the comparatively meagre data available on this subject. An article reporting tests on a 15-h.p. Diesel engine contains an explanation of the fact that while small engines show a decrease of additional friction with an increase of lead, large engines behave in an exactly opposite manner; the same article establishes also the relation between the temperature of cooling water and internal friction in the engine at various loads on the engine, and gives data on the maximum temperatures prevailing in the engine during the combustion part of the cycle. It is brought out that the maximum temperature is found not at maximum load on the engine, but at a certain average indicated pressure.

Particular attention is called this month to the section on Machine Shop processes. Guillet and Bernard discuss various methods of producing limited case-hardening; that is, preventing certain parts of the surface from becoming carburized. After discussing the use of copper and nickel deposits on the parts of the surface where carburization is not to take place, the authors show that tin, notwithstanding its low melting point, can be used to advantage in certain cases.

In the same section Grebel describes a special type of furnace for heat treatment of metals heated by coke-gas mixed with heavy-oil vapor, the oil not being passed through the fuel bed, but vaporized separately. Further will be found an extensive abstract of the very interesting account of tests made on various kinds of tool steel by Denis, of the French Army.

In other parts of the Foreign Review will be found articles on improvements in the design of Parsons turbines, strength of cement cubes, power transmission by belt and ropes, etc.

An interesting paper on boiler superheaters and their performance is abstracted from the proceedings of the Franklin Institute. W. D. Ashton Bost, in a paper before the Institute of Marine Engineers, discusses the various uses of wood charcoal, and gives data in connection with its use on ships as an insulating material on refrigerating apparatus. According to figures from Board of Trade reports it would appear that the results of fire are less disastrous where wood charcoal is used for insulation than where the incombustible silicate cotton is employed for this purpose. Data on steam regenerators, a piece of apparatus about which there appears still to be a good deal of question, are presented in several papers before the Engineers' Society of Western Pennsylvania.

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

FOREIGN REVIEW

Fuels and Firing

MACHINE MADE PEAT AND THE PROCESS OF BARON TRAUBENBERG (*Mashinofarmovanniy torf i sposob barona Traubenberga*, Professor K. Blacher, *Proceedings of the Russian Imperial Technical Society* (in Russian), vol. 48, no. 5, p. 97, May 1914, 15 pp., 7 figs. *d*). The author discusses the machine method of peat briquette manufacture in general and the process of Baron Traubenberg in particular. The essential elements of this latter are first, in the operation of peat digging, the shifting of the bucket arm so as to make it possible to take peat from various depths of the bog separately; and second, the placing of the dredge conveniently with respect to the bog so as to prevent breakages of the bucket arm. The next novelty in the process is based on the fact observed by the inventor that it is quite easy to eliminate water mechanically from peat taken from the upper part of the bog, while it is practically impossible to accomplish this with the fat peat lying at the bottom of the bog. He introduces, therefore, a method of mixing the two kinds of peat, having previously mechanically dehydrated the softer peat of the upper layers of the bog. The system therefore involves the use of two conveyors, a rear conveyor and a side conveyor. The upper level of the peat is taken by the rear conveyor which delivers it to a press for forcing out the water; then the peat is mixed right in the machine with the heavy peat from the lowest level, taken by the side conveyor. It appears that the peat obtained in this manner is much more stable than one not made of a mixture of the two kinds.

The author, together with his assistant, engineer Douglas, have found the following methods for the determination of the *stability of peat:* they made little peat balls weighing 50 g and dropped them from a height of 1 m on a glass plate. In accordance with the stability of the mass the balls spread more or less. The ratio between the two diameters of the mass after it has spread, normal to one another, to the square of the diameter of the ball expressed the stability of the mass in percentages, equivalent to the increase in the projection of the mass after it has struck the glass. A table given in the report shows interesting figures where the projection of the ball increased from 33 to 227 per cent. As regards the properties of the briquettes made by this process, it may be considered to be established (statement of the author) that such briquettes are more regular, less

liable to crack, and when they do crack, form regular and uniformly distributed lines. The author describes an extensive test made by this process in Russia.

Novelties in Solid Fuel Firing Plants (*Neuerungen an Feuerungsanlagen für feste Brennstoffe*, Pradel, *Feuerungstechnik*, vol. 2, no. 16, p. 273, May 15, 1914, 4 pp., 10 figs. *d*). The article describes various new inventions proposed for use in firing with solid fuels. Among other things Fig. A shows a device for cooling the furnace front, patented in Germany by the Vulkan Shipyard Company. This de-

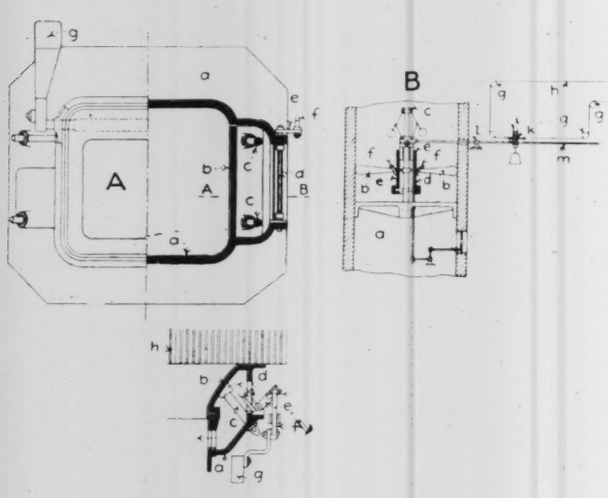


Fig. 1 Novel Appliances for Firing Solid Fuels

vice permits very effective cooling of surfaces forming the parts of the frame which are particularly exposed to the heat of the furnace, by means of a stream of air regulated by a special distributor. The parts which are especially in danger of being affected by the heat are built-in in the firedoor frame as separate pieces, so that they can be taken out and put in again by a simple manipulation of a few bolts without the necessity of pulling down the entire firedoor installation. As shown in Fig. 1A, the removable part *b* is connected with the fire-door frame *a* by an anchor bolt *c*. The cooling is done by means of a compressed air stream going from the Howden draft through the regulating valves *d* which are connected with the firedoor by a lever device, and, according to their setting, provide a more or less effective cooling of the removable pieces *b*. From the latter the preheated air flows through the openings in the frame *a* to the combustion chamber. The weight *g* is connected by means of a knee-lever and an adjustable intermediate piece with the lever *f* which may be shifted in its bearings and which in its turn moves the forked-shaped lever *e* and thereby determines the position of the valve *d*. This valve in its turn opens in such a manner as to permit the flow of the incoming cooling air on the exchangeable part *d* of the frame *a*. When the firedoor is opened the valve *d* is closed.

The same article describes the peculiar arrangement for the regulation of draft in a smokestack, patented in Germany by E. Hartz. It consists of a centrifugal governor located in the smokestack and more or less closing the free opening of the latter. This governor is regulated by means of a windwheel, driven by the smokestack draft. Fig. B shows one of the possible designs of this governor, consisting essentially of the windwheel *b* built-in in the smokestack *a* and the governor *c* sitting on the shaft of the windwheel. Blades of the windwheel are rotatable about their horizontal longitudinal axis running in the journals *d*, and rotate with the speed corresponding to the existing draft in such a manner that the opening of the smokestack is closed more or less. This rotation is regulated from the governor *c* through the spindle *e*, set on the governor sleeve and connected with the blades of the windwheel through the gear segments *f*. When the draft in the smokestack is at its maximum, the governor arms are at their maximum, the angle of rotation and the blades of the windwheel are so far thrown out around their longitudinal axis by the gear *e f* that the opening of the smokestack is entirely closed. This cuts out the draft and causes the arms of the governor to sink down which again causes the blades of the windwheel to open fanwise. In order to adjust the governor to a certain draft capacity from the outside an endless valve rope *h* is provided, starting from the furnace and going over the rollers *g* to the governor. This rope is provided with a guide piece *i* with the slot *s* in which moves the axis of the roller *k* with the weight hanging on to it. The roller runs along the lever *m* supported on bearings *l* and connected on to the governor sleeve. By pulling on the rope *h* in either direction, the weight is disposed of so as to bear on the lever *m* and the governor may be brought into any desired position of adjustment.

Firing of Coal and Anthracite, and Utilization of Their Heat in the Boiler Room (*Verbrennung von Steinkohlen und Anthrazit und Verwertung ihrer Wärme im Kesselhause*, Professor Kirsch, *Feuerungstechnik*, vol. 2, no. 18, p. 308, June 15, 1914 (and following). *de*). The article describes the properties of Russian anthracite coals and the various methods of utilization of their heat in the boiler rooms. It goes into considerable detail as regards the construction of grates used with anthracite fuel and describes the Kudlitz, Meldrum, Wilton and other types. The following are the constructions developed especially in Russia; the *Idelson* grate (Fig. 2A). Contrary to the Wilton grate, it has a level surface which, in order to make the installation easier, is so built that it can be removed. The construction, however, is more complicated and permits the flow of air to

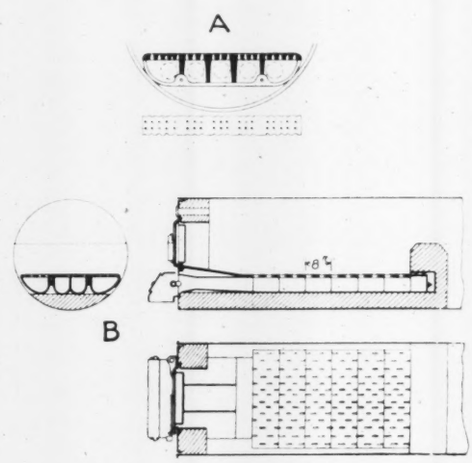
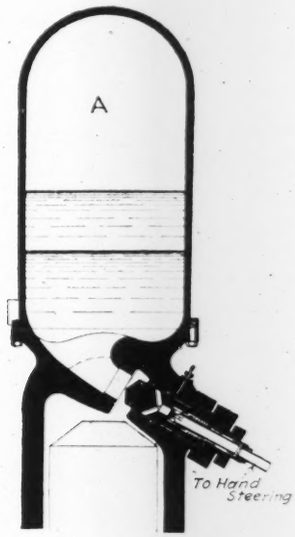


Fig. 2 Idelson and Pawlowski Grates for Anthracite Coal

easily cool the fire owing to lack of metallic contact between air and the grate bodies. A simpler and more durable construction is that proposed by Pawlowsky, shown in Fig. B. The single members are considerably wider than either in the Wilton or Idelson grate (about 8 in). The grate is also level and the openings are in the form of slots. The single members are set on top of the connecting bolts, just as is in the more recent designs of the Wilton grate.

Tests made by the author have shown that an uninterrupted delivery of coal does not produce any improvement in the combustion process, but he still finds it preferable to use mechanical stoking where large amounts of anthracite are burned per unit of time as it produces a decrease in the manual labor which must not be left out of consideration.



All the above described grates can be easily provided with such a mechanical stoking, which, with anthracite firing specially, has a further advantage that it does not permit very large lumps of coal to fall on the grate, the use of small pieces improving the process of combustion in all the above grates. These were provided with very simple steam jet apparatus, consisting of an air nozzle with a steam nozzle built in. Regulation of such an apparatus is easily effected by varying the steam pressure by means of a throttle valve. It is advisable to provide this kind of apparatus with a manometer so as to lighten the work of the fireman and to show that he does not spend too much steam on the blast. It is also advisable to have some simple pressure measuring device connected at one end with the ash-pan and the other with the fire-room. This simple and cheap apparatus will permit one to get an idea of the uniformity of the fuel bed, the degree of cleanliness of the grate and the stresses occurring in the latter (the original article is not finished).

Hydraulics

On Water Admission Steering Gear for High Speed Forging Presses and their Investigation by means of No Load Diagrams (*Über Vorfüllsteuerungen für Schnellschmiedepressen und ihre Untersuchung durch Pressenleerlaufdiagramme,* Adolf Kreuser, *Stahl und Eisen*, vol. 34, no. 25, p. 1043, June 18, 1914, 4 pp., 13 figs. *de*). In order to reduce the resistance occurring in the admission of the pressure water, as well as the concomitant fall of pressure, the J. Banning Company of Hamm in Germany has designed the special valve shown in Fig. 3A. One can see at once the advantageous path of water on account of the inclined position of the valve and because of the fact that the valve opens directly into the large water space of the pressure cylinder. The valves are also easily accessible; a valve like that shown in Fig. A has been used on forging presses with capacities up to 1000 tons (metric, equal to 1100 short tons).

A clear conception of the internal relations in a hydraulic press during the no-load stroke can be obtained by means of indicator diagrams. Figs. B to D show the indicator diagrams taken during the downward stroke of the plunger of a high-speed hydraulic forging press, used on the Italian State Railways. The water end pressure in the tank, at the time the diagram B was taken, was 0.9 atmospheres gage. The time which the plunger required for the no-load stroke of 0.53 m (1.69 ft) was 1.0 sec., measured by a stop-watch, this making the average downward velocity of the press plunger 0.53 m (1.69 ft.) per sec. On account of the hydraulic pressure, the plunger was receiving throughout its path an additional acceleration. Previous to taking diagram C, the water pressure in the tank was reduced by blowing off part of the compressed air and as diagram C shows, the water pressure was producing an acceleration on the plunger during its nearly entire no-load stroke. The hydraulic end pressure in the press cylinder was just equal to atmospheric pressure so that shortly before the end of the stroke, the water did not affect the motion of the plunger any more. Previous to taking diagram D, the water pressure in the tank was still further reduced, and the hydraulic pressure produced an acceleration of the plunger motion only at the beginning; after the plunger had traveled through part of its stroke, the water pressure in the cylinder fell below the atmospheric, and the plunger carried the water with it by suction, just as in a suction pump. Here also, however, the process in the press cylinder occurred without shocks, as the water column was not broken, and the cylinder was full of water at all positions of the plunger. The average downward velocity of the press plunger was in this case 0.44 m (1.44 ft.) per sec.

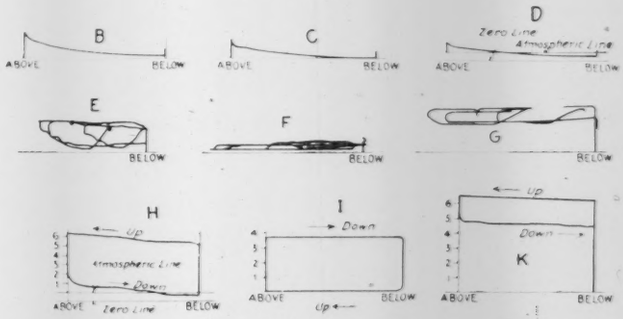


Fig. 3 High Speed Hydraulic Forging Press Valve and Indicator Diagrams

The diagrams E, F, and G have been taken from a steam hydraulic high speed forging press, used in the central shops of the Royal Railroads at Meiningen. At the same time when these diagrams were taken, special indicators were used

to indicate the various spaces influenced by the no-load stroke, namely, in Fig. E, the press cylinders, in Fig. F, the upper steam return space and in Fig. G, the lower steam return space. The diagrams indicate the increase and decrease of forces during the no-load run, produced by causing shorter or longer strokes to follow one another. Of particular interest in this case, is the variation of steam pressure in the lower steam space. The steam consumption for the no-load stroke in the present case is very small because the live steam admitted to the lower steam space during the working stroke has in every instance found non-consumed steam of about the same pressure still there. Figs. H and K show no-load stroke diagrams for the upward and downward strokes of the press plunger of a steam-hydraulic high speed forging press when the most rapid reversal by hand operated lever was used. The press is of the same construction as that to which refer the diagrams E, F and G. The author discusses further the frictional resistances in the press plunger action. In addition to the forces shown by these indicator diagrams, the press plunger has to overcome also frictional resistance, which can in the case of a slow motion of a plunger be analytically determined from the indicator diagrams. The author shows how this resistance can be obtained from the diagram H. The frictional resistance has a certain importance on the motion of the plunger and therefore must be reduced as much as possible.

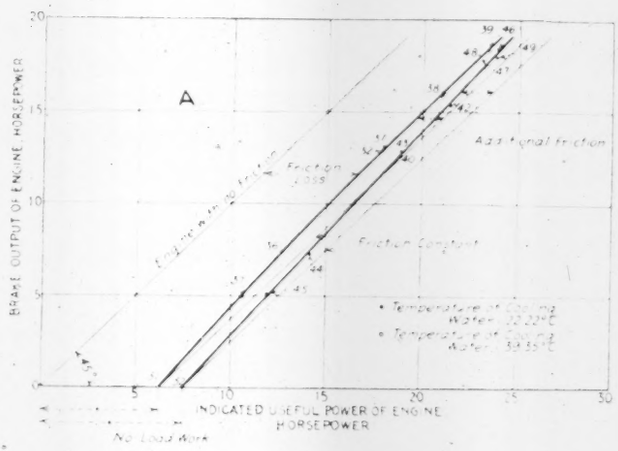
The Turbine Plant of the Günther and Richter Paper Manufacture in Wernsdorf (Saxony) Built by Escher, Wyss and Co. of Ravensburg (*Die Turbinenanlage der Papierfabrik von Günther and Richter in Wernsdorf (Sachsen), erbaut von Escher, Wyss & Cie. in Ravensburg*, Fr. Freytag. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 26, p. 1033, June 27, 1914 (and following), *d*). The article describes the turbine plant of the paper mill of Gunther & Richter in Weinsdorf (Germany). The new installation of the water turbines was put in in 1912, when several plants, formerly separate, were united in order to make their operation more efficient and economical. There was formerly a set consisting of one Girard turbine and one Francis turbine with vertical shafts which with a 5 m. head (16.4 ft.) could deliver at most 200 h.p. The new installation is calculated to deliver up to 1500 h.p. The installation was especially difficult to design owing to the water-power plant and mill where the power is used being pretty well apart and through the fact that while twin turbines with horizontal shafts had to be selected, a variable water level required the division of the power plant into three groups. It was therefore decided to put up the turbines with a high suction upper water level (Escher, Wyss and Co. system) and to connect them direct onto the shaft of the polishing plant. The middle line of the shaft lies 440 mm (17.3 in.) above the normal upper water level. The runners have an entering diameter of only 600 mm (23.6 in.) and the lower edge of the runner is at least 140 mm (5.5 in.) over the upper level of the water. The turbines (three Francis twin type) of equal dimensions are directly connected to two horizontal shafts. Their runners have a speed of 237 r.p.m. They all have rotatable blades with automatic regulation and hand regulation. The water comes onto the distributors from below and each turbine is covered over by a cast iron horizontally divided arc-shaped cover whereby a reliable airtight water chamber and convenient flow of water is obtained. In the case of material repairs, these covers may be easily lifted off, in which case the entire turbine is fully accessible from the machine shop.

Internal-Combustion Engines

Tests of a 15 H.P. MAN Diesel Engine (*Untersuchungen an einem 15 pferdigen MAN-Dieselmotor*, F. Münzinger, *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 26, p. 1049, June 27, 1914, 7½ pp., 24 figs. *e*). The article describes tests on a vertical Diesel engine built by the Augsburg-Nürnberg Works (the tests were performed in the mechanical laboratory of the Berlin Technical High School). The engine was rated at 15 h.p., has a working cylinder 215 mm (8.4 in.) in diameter and 340 mm (13.3 in.) stroke and compressor cylinder, in two stages, 100 mm (3.9 in.) stroke running at from 230 to 240 r.p.m. The load on the engine was put on by means of a Prony brake of special construction, while the diagrams have been taken by a Maihak indicator of convenient design and properly calibrated.

One of the questions in the construction of gas engines which cannot be as yet considered to have been cleared up is whether the friction work of an engine increases or decreases with increasing load; that is, whether the supplementary friction of an engine is positive, constant or negative. To determine this, two series of tests with variable load and variable temperature of cooling water were undertaken. Fig. 4A indicates clearly the great influence of the temperature of cooling water on the amount of friction work. If two parallel lines be drawn through the no-load points of the two tests at 45 deg. to the horizontal, then the horizontal distance between these two curves and the curves passed through the points obtained by actual tests, will indicate the magnitude of the additional friction in both series of tests. The additional friction decreases with the increase of load. In order, however, to establish whether the decrease of the additional friction with the increase of load is peculiar only to the engine tested or common to all Diesel engines, the author calculated results for other sizes upon which data are available. His curves show that when the load on an engine increases, there sometimes occurs an increase and at other times a decrease in the work of friction, but a certain law can be seen to cover this variation when the size of the engine is taken into consideration, since it appears that with an increase of load the small engines show a decrease of additional friction while the large engines show an increase. The main reason why the additional friction would decrease with increasing load is to be looked for in the decrease of piston friction. The plunger piston of a Diesel engine is usually turned in such a manner that its lower end directed towards the external atmosphere has a slighter angle of incline than the upper end. When the load increases the temperature of the wall, along which the cylinder runs, increases also and as a result the cylinder expands more than the piston and this permits an increase of play between the piston and cylinder. Of course the diameter of the piston increases also under these conditions, but since the piston in the part directed towards the combustion space is narrower than the cylinder bore, even at a maximum load, no jamming between the piston and guide can occur; the expansion of the lower part of the piston will always be less than that of the surfaces of the cylinder. In addition to the favorable action of the increase of piston play on the reduc-

tion of friction, the increased lubricating effect of the lubricating oil, due to the higher temperature of the cylinder walls, also acts towards reducing friction. This explanation of the decrease of additional friction with increase of load is supported by the great influence of the temperature of cooling water on friction losses shown by the present tests. The rise of the average temperature of the cooling water in the jacket of the cylinder increases the play between piston and cylinder in the same manner as the increase in temperature of the cylinder which is produced by an increased transmission of heat from the gas mixture to the cooling water. This does not yet answer the question why in larger engines the friction increases with increase of load. It appears, however, that from a certain cylinder diameter on different conditions come into play, viz., the variation of expansion of piston and cylinder play smaller parts and at higher load the smaller piston friction is more than compensated by the



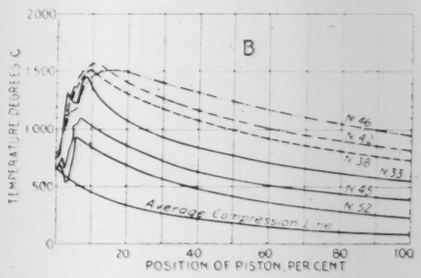


Fig. 4. Tests of a 15 h. p. Diesel Engine. (A) Relation Between Friction and Load, (B) Temperatures Occurring in the Cylinder

increase of friction in the bearings, etc. The present tests do not, however, give a complete answer as to this fact.

The author proceeds to establish, largely by graphical methods, the "heat balance" of the engine. He finds that the indicated theoretical efficiency of the Diesel engine process increases with the decrease of load owing to the rise of the expansion ratio. The thermal efficiency of the theoretical cycle was found by calculating the end compression pressure and by assuming that the heat was brought in at that particular pressure. Then the compression and expansion lines were plotted by assuming for the temperatures corresponding to various positions of the piston, the values calculated from the usual formula which takes into account the variation for the exponent for various temperatures.

It is particularly important to know how the temperature varies during combustion and expansion and what the maximum temperatures obtained in the engine are. While this latter could not be calculated with absolute certainty, the possible errors are so small that the data can be fully used for all practical purposes. Fig. B shows that the maximum temperature in the engine does not exceed 1500 to 1550 deg. cent. (2732 to 2822 deg. fahr.) and that the highest temperatures occur not at the highest load on the engine, but at an average indicated pressure of about 7.4 atmospheres. From there, the upper part of the temperature curve becomes generally flatter and remains in the neighborhood of 1500 deg. cent. (2732 deg. fahr.).

Machine Shop

Limitations of Case-Hardening and Diffusion Through Solids (*Les réserves en cémentation et la diffusion dans les solides*, L. Guillet and Victor Bernard. *Bulletin de la Société d'Encouragement pour l'industrie nationale*, vol. 121, no. 5, p. 588, May 1914, 30 pp., 32 figs. *pe*). The article discusses methods of carburizing by which certain sections of the surface can be left untreated and also takes up the subject of the diffusion of metals through solids. As regards the first, the author calls attention to the usual methods of protecting the surface of case-hardened articles in the parts where no carburization is desired. This may be done by either of three methods, that is (1) covering the parts to be protected by some refractory material, (2) "piping," and (3) case-hardening the entire surface and then cutting off a certain thickness on the parts where no case-hardening is desired, such parts having previously been made somewhat thicker so as to compensate for the material removed in the later process. The method which appears to be most convenient for general purposes is that of covering the parts to be protected by a layer of some metal which will prevent carburization. Such a metal must satisfy the following conditions: (1) It must be solid at the temperature of the operation as otherwise it would flow and leave the surface unprotected; (2) it must not allow the passage of the substances which produce carburization, and (3) it must be easy to apply under shop conditions and, after carburization, if necessary, must be easy to remove. So far there are two metals which can be generally considered, copper and nickel, but the author has made some experiments with tin which appears to be also applicable in this connection notwithstanding its low melting point. There are several methods of laying copper over iron. The immersion of the article into a solution of copper salts or the painting of the parts of the surface by such a solution appears to be at first sight very attractive on account of its simplicity, but no good results could be obtained in this way partly owing to the very slight thickness of the metal layer and partly because of its irregular structure and lack of unity and adherence. A far more reliable method is electrolysis. The authors tried to determine the minimum thickness necessary and sufficient for an absolute protection of iron against carburization under conditions prevailing in the case-hardening process, these conditions being established by the thickness of the carburized layer obtained in the parts not protected by copper. These results will be reported below. The third method of coppering an iron surface was by the Schoop process of metalization which as compared with the electrolytic deposit gives an irregular grain-like layer and unlike the other does not admit of a sufficiently precise measurement of

TABLE 1 RELATION BETWEEN THICKNESS OF PROTECTING LAYER OF COPPER, AND AMOUNT OF PROTECTION AFFORDED

Temperature of Case-Hardening, Deg. Cent.	Thickness of Carbonization in Not Protected Parts, mm.	Thickness of the Protecting Layer of Copper (1/100 of mm.)	Carbonization of Protected Parts
1000	1.0 to 1.1	1 to 2	slight
1000	1.0 to 1.1	2 to 3	absolutely none
1000	1.8 to 1	1 to 2	considerable
1000	1.8 to 2	3 to 4	absolutely none
850	1.0 to 1.1	1 to 2	absolutely none

thickness. On the other hand, however, the metalization process permits obtaining with great rapidity a fairly thick layer and therefore does not essentially require a knowledge of the minimum sufficient thickness of layer. In the case

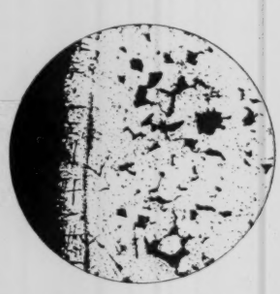


FIG. 5 MICROGRAPH OF A PIECE PARTLY PROTECTED IN CASE-HARDENING BY A LAYER OF TIN

of electrolytic deposition of copper, the measurement has been effected in 1-100ths of a mm. The electrolysis was obtained in a cyanide bath and the carburization made from a mixture of 60 parts by weight of charcoal and 40 parts of barium carbonate. Results obtained are shown in Table 1, which indicates that the thickness of the deposit necessary for the protection of the iron against case-hardening is a function of the temperature and duration of the carburization process.

The nickeling of iron can so far be done only by electrolysis as pulverization methods have not yet been applied to this metal. Tests similar to those on copper have been made also for nickel deposited from a double electrolyte of sulphate of nickel and ammonium. It appears, however, that contrary to the case of copper, nickel is not a good protective agent and only delays the carburization to a certain extent, which shows that it is permeable to carbon monoxide.

Tests have been also made with protecting iron by a layer of tin which is of interest on account of the great simplicity of the application of this metal, and it appears that notwithstanding its low melting point it gives very good protection. Its use is, however, limited to plain surfaces which can be maintained horizontally during the carburization. Otherwise, it gives a very regular protection or none at all. In addition the edge of the piece appears to be strongly altered (Fig. 5). The above shows that practically copper alone gives the solution of the problem of protecting iron against case-hardening by means of a metallic deposit. As regards the best method of applying this deposit, the Schoop process is extremely simple, but unless it is used in the same shop for other purposes, may prove too costly on account of the large cost of installation and royalties paid. The electrolytic process is cheap to install, practically automatic in operation, consumes very little copper, but is inferior to the Schoop process from the point of view of localization of deposits. The second part of the article is devoted to discussion of the diffusion of metals through solids.

FURNACES FOR HEAT TREATMENT OF METALS RUNNING ON PRODUCER GAS ENRICHED BY HEAVY OIL (*Fours pour le traitement thermique des métaux, chauffés au gaz de gazogène enrichi à l'huile lourde*, A. Grebel, *Le Génie Civil*, vol. 65, no. 7 and 8, pp. 136 and 160, June 13 and 20, 1914, 5 pp., 9 figs. *dgc*). The article describes in detail the use of producer gas enriched by tar-oil for heat treatment of metals and in particular the furnace and methods used by the French concern, "Air et Feu" (Air and Fire). The Air and Fire system furnace shown in Fig. 6A and B comprises as its essential parts, gas producer *A*, carburetor *B*, the combustion chamber *C* and heat recuperator *D*. When the operations are such that the doors have to be frequently opened as, for example, in forging, stamping and tempering, the combustion chamber is placed on an elevation so as to create a slight pressure of the gases in combustion. In the furnaces designed for long operations with the doors closed air tight, the design shown in Fig. C to E, with all parts very nearly in one plane, is preferable. Fig. F shows how the oil is brought to the carburetor B and how it is used for igniting the producer gas in the mixing chamber every time such an ignition is desired. The blast used permits obtaining intensive gasification as well as short and constantly hot flame, but on the other hand does not permit obtaining regular and uniform temperatures in an enclosed space, and as a consequence it does not guarantee in any way a uniformity in the combustion of the flue gases and their content of free oxygen as required in many heat treatments of metals. When the blast is used, therefore, either a complicated system of blowing or the most strict supervision of the regulation of combustion or both have to be maintained. To obviate this difficulty, the author, under whose patents the Air and Fire system furnaces have been designed, has undertaken to have his furnaces work at low drafts; for furnaces of average commercial size and larger, it appeared rational to adopt the independent type of gas producers, built in one unit with the combustion chamber and heat recuperator so as to reduce radiation losses and utilize to the maximum extent the latent heat of gases coming from the producer. To build and operate special producers for rich gases from fuel containing large amounts of volatile matter is expensive, while coke gas producers with a slow rate of production and simple grates are very easy to build and operate. Gas coke which is light and brittle, is not used for metallurgical purposes or for small furnaces with direct flame when it is desired to obtain a high temperature. It is, however, quite convenient for use in gas producers with low draft and, on account of its low price, very desirable for use in heat treating furnaces, if it can be used conveniently, which as the author claims, can be done in the furnace described in the present article. The quantity of water introduced into the producer is controlled by means of regulator *a* of a construction analogous to that of the oil regulator *b*, shown in Fig. F, and the construction of which will be explained in more detail

below. This is done because the amount of water admitted to the producer has to vary in accordance with the rate of output of the latter. In order not to cool the producer furnace too much while it runs at low rate of output, the amount of water admitted must be then extremely small, while, when large producers are working at full rate, up to one lb. of water per lb. of coke can be admitted.

This statement of the author is of importance because of the opinion expressed by certain designers of producer furnaces who, without denying that the amount of hydrogen in the producer is of advantage from the point of view of the amounts of heat utilized in the combustion chamber, state that the products of combustion must not affect the articles submitted to the heat treatment, and that if the combustion has been perfect and correct, without an excess of air, they must in addition to nitrogen contain only carbon dioxide and steam; that further, the latter tends to decompose when in contact with hot metal and to oxidize it. From these correct

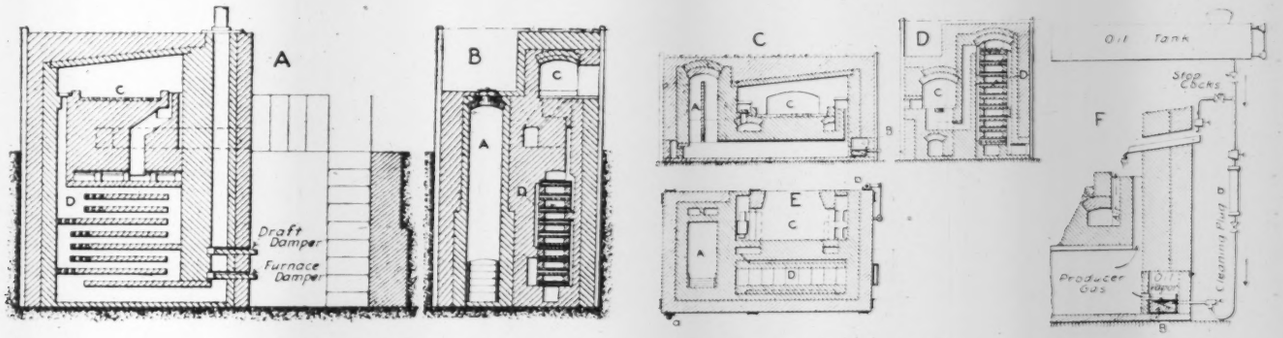


Fig. 6. A to E Air and Fire Company's Furnace for Heat-Treatment of Metals

premises, they make a wrong conclusion, namely, that the amount of water admitted into the producer must be reduced to as low a limit as possible. What may be called neutral combustion, that is, one producing neither carburation nor oxidation, varies with the circumstances. In the case of autogenous welding where the temperature of the flame is in excess of 2000 deg. cent. (3632 deg. fahr.) and the products of combustion are not diluted by nitrogen, the carburation is sometimes to be expected while oxidation is practically imminent, and is all the more to be feared as it compromises the results of the operation. But it is easy to establish by calculation and verify by direct tests that in the products of a perfect combustion of a mixed-coke-gas containing, for example, 13 per cent of hydrogen and only 22 per cent of carbon monoxide, the steam contents do not exceed 9 per cent, so that, at the usual low temperatures below 1500 deg. cent. (2732 deg. fahr.), such as occur in furnaces under consideration in the present case, there is much less danger of oxidation when mixed-coke-gas is used than when water gas or especially coal gas is used, and, further, the system of regulation used in the present furnace makes it possible to admit as little water as desired; on the other hand, even when a liter of water is admitted per kg. of coke, all the water is certainly vaporized before it reaches the grate through the intense radiation directed towards the stationary trough which is located within the door and where the water arrives first. With mixed coke producer gas having a hydrogen content of approximately 12 to 15 per cent escaping hot from the producer and burned with not-blown secondary air, heated previously by the flue gases, the temperature of 1450 deg. fahr. (2642 deg. cent.) may be considered as an absolute maximum even in small furnaces.

In order to obtain higher temperatures one must have recourse to the use of richer fuels, preferably fuels comparatively poor in hydrogen. Neither acetylene nor gasoline vapor nor even coal gas can be considered in this connection owing to their high prices and only less refined products such as heavy tar-oils (which have already been successfully used in special furnaces) can be considered for this purpose at a comparatively low price. They have an average heat value: upper limit 9450 cal. (17010 B.t.u. per lb.), and lower limit 9050 cal. (16290 B.t.u. per lb.). Notwithstanding the great difference in the initial price of 1000 heat units as gas coke or heavy oil, the heavy oil furnaces could stand comparison with the coke producer gas furnaces for small units intermittently used when developing a high temperature.

Whereas in certain kinds of burners provided with a producer or "boiler," the oil is simply gasified, in the present design the carbureter *B*, Figs. C and F, has been placed in the region of the gas flue where the temperature of the oil does not exceed 360 deg. cent. (680 deg. fahr.). In this way, the total vaporization of the oil may be secured and at the same time "cracking" is avoided. The temperature of the gas coming out from the producer has been somewhat reduced in order to have in the combustion chamber a gas free from dust; still, the temperature is too high to let the gas flow over the surface of the oil. The current of the gas carries, however, vapors as they are formed. The surface of vaporization in the boiler *B* has a horizontal section, decreasing with consumption of the oil. The oil vapors, not previously denatured by heat, become diluted in the mixed gas of the producer, and thereby particularly susceptible to enter into an intimate mixture with the air of combustion. In this way, the gas is made richer without there occurring a transformation of the carburizing material, contrary to what happens in the case of gas producers, where tar or heavy oils are injected over the coke bed or incandescent refractory materials.

Combustion Chamber. Although the diffusion of the very heavy vapors of the coal-tar oil through poor gas facilitates their complete combustion, the question of the quality of the flame still remains very delicate. The burners have been designed in such a manner as not to create any localized combustion and exaggerate the parallelism of the currents of gas and air. It was found that contrary to what has been stated in certain books of theory, it is not necessary, in order to obtain a uniform temperature, to extend the length

of the flame so that "the combustion should occur outside of the furnace." If this is done, the best temperature of the flame is lowered owing to the retardation of the combustion and, in addition, reducing and oxidizing streamlets of gas and air are created, producing an undesirable influence on the heat treatment process. When the thermal potential of the gases of combustion is sufficiently above the temperature at which the heat is utilized, the exchange of heat is more rapid and the heating of the heat-treated pieces can be carried on with a quiet flame; the caloric efficiency is better than in the case when the velocity of circulation of the flames is intensified, and further, the heating atmosphere is more homogeneous. In heat treating furnaces, it is therefore important to select in a judicious manner the length of the flames, disposition of the burners and the outlets for the flames. As regards the *recuperation of the heat*, only a simple recuperation in the secondary air of combustion has been utilized.

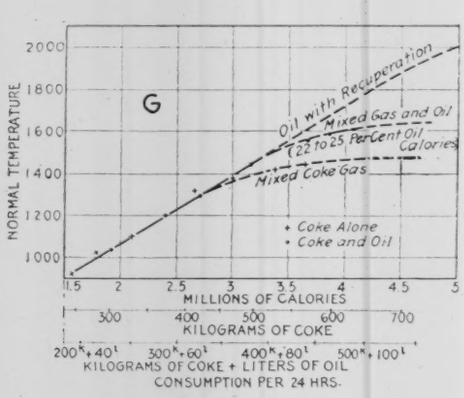


Fig. 6, G Heat Rate of Consumption Curves for Furnaces of Various Types

The recuperation on the primary air which theoretically would be of peculiar interest for furnaces operating at a normal temperature in excess of 1500 deg. cent. (2732 deg. fahr.) leads to complications and to losses in recuperators, larger than the saving due to the large losses of recuperators by radiation, besides making the conservation of the producer grates difficult, and the regulation and maintenance of operation of the furnace, more delicate. It is hardly possible to recuperate any heat from the gas which comes out hot from the producer and is scarcely cooled at all in the dust cleaning flue. In Fig. A and D, it will be noticed that the recuperator *D* is considerably larger than in the furnaces, the surface of which is too much restricted. Last year a number of tests on a horizontal type of furnace of the above described design heated by coke exclusively or coke and heavy oil together, were made by J. Conor, a gentleman apparently connected with the Air and Fire concern. In order to obtain comparable results, the combustion chamber of the furnace was kept closed and filled with refractory materials, and the same conditions were maintained in the other coke gas or oil furnaces, which were placed in parallel with the Air and Fire Company's unit.

The article describes in detail the measurements taken and instruments used for that purpose. The proportion of the heavy oil in case of mixed-combustion varied about two liters per ten kg. of coke which represented the ratio of approximately 23.5 per cent of the total number of heat units consumed. The curves in Fig. G represent normal temperatures as a function of the number of calories expended during 24 hr. (all the tests were reduced to a 24 hr. unit). This number was calculated by assuming 6400 cal. per kg. (11,520 B.t.u. per lb.) as the upper heat value of coke and 9900 cal. as the upper heat value of a liter of oil (density 1.06, upper heat value per kg., 9425 = 16,965 B.t.u. per lb.). It may be stated that at from 900 to 1300 deg. cent. (1652 to 2372 deg. fahr.), the normal temperatures have been found to be substantially proportional to the expense in calories per 24 hr., whether from gasified coke, or from gasified coke and vaporized oil. From 1300 deg. cent. (2372 deg. fahr.) up, the normal temperatures with poor gas from coke producers only, increase less and less rapidly and tend towards an asymptote at about 1450 deg. cent. (2642 deg. fahr.), from 1300 deg. to 1475 deg. cent. (2372 to 2687 deg. fahr.), approximately, when mixed, firing is used with 100 kg. of coke per 20 l. of oil (76.4 per cent of coke-calories, and 23.6 per cent of oil-calories), the normal temperatures continued to rise in proportion to the expenditure in heat units, and tend rapidly towards an absolute maximum which may be estimated to be about 1650 deg. cent. (3002 deg. fahr.). To exceed this temperature, the carburation of the oil would have to be forced, and it alone could give a much higher temperature under similar conditions of heat recuperation without "cracking," all other conditions being equal. It appears, therefore, that in a given furnace, the number of calories circulating in the combustion chamber cannot be increased indefinitely and a limit is laid on account of the resistances opposing the movements of the gas and combustible vapors, air of combustion and flue gases. On the other hand, it is not wise to increase the proportion of the oil vapor too much in the mixed-gas, especially at low temperatures with small drafts, since owing to insufficient dilution, it is difficult to burn heavy oil, well. That was the reason why the present tests have not gone behind a 30 per cent ratio of oil-calories in the mixture.

A diagram in the original article taken from tests gives curves for four rates of consumption per hour arranged in such a manner that, in pairs, they might be comparable with one another. The curves of the rise of temperature in the combustion chamber are given as functions of time, the combustion chamber being cooled by the opening of the door to temperatures of 500, 750 and 900 deg. cent., respectively (932 to 1382 and 1652 deg. fahr.). When two million calories per day are consumed in the furnace, the passage from 750 to 900 deg. cent. takes about 1½ hr. with mixed fuel and 3 hr. and 45 min. when poor gas alone is used for heating. With a consumption of three million calories per day, the passage from 900 deg. to 1200 deg. cent. requires, with mixed heating, 1 hr. and 30 min., and with poor gas alone, 3 hr. and 15 min. While the time necessary to re-establish the normal temperature is not entirely lost as far as the operation of heat treatment is concerned, it is easy to see, when such operations are of short length and have to be frequently renewed, how a rapid method of raising the temperature affects the cost of manufacture expressed by a larger consumption of heat or a shortening of the time of operation.

Investigation of the General Properties of Tool Steels (*Étude sur les propriétés générales des aciers à outils*, M. Denis. *Revue de métallurgie*, vol. 11, no. 6, p. 569, June 1914, 100 pp., 43 figs. *ecA*). The article pre-

sents the results of quite an extensive investigation on the efficiency and output of tools and tool steels. It is divided into three parts: First, discussing the method of tests and heat treatment of various kinds of tool steels; second, the detailed data of the tests, and third, conclusions and general results derived from the data in part two. The third part only will be abstracted here.

The tests can be divided into two main classes, cold and hot tests. As regards the first, two main points, sensitiveness to tempering, and hardness and resilience in various types of treatment have been considered. The results of all the tests are combined in Table 2. The system used by the author is to give a mark 20 to a steel, the Brinell hardness of which is not influenced by an increase of 50 deg. cent. (90 deg. fahr.) in the temperature of tempering. This mark is decreased by as many units as the decrease in the hardness, for an increase of 50 deg. cent. in the temperature of tem-

TABLE 2 CLASSIFICATION OF VARIOUS KINDS OF TOOL STEEL IN ACCORDANCE WITH DATA OF TESTS OF COLD WORKING

Kind of Steel	Sensibility to Tempering	Sensibility to Successive Temperings	Average Mark for the Three Typical Treatments
Special S_3 (extra-hard chromium)	18	13	18.33
Carbon C_6 (1.14% carbon)	17	19.5	17.9
Carbon C_7 (1.26% C)	13	14.5	17.25
Carbon C_4 (0.91% C)	19	15	17
Special S_1 (very hard chromium)	17	13.5	16.9
Special S_2 (very hard chromium)	18	18	16.85
Special S_5 (tungsten)	16	15	16.66

pering, contains tens of Brinell units. For example, if a steel has a hardness of 800 Brinell units at the best temperature of tempering of 780 deg. cent. (1436 deg. fahr.) and a hardness of 760 for a temperature of tempering of 830 deg. cent. (1526 deg. fahr.), then the mark for the sensitiveness of tempering would be 16, that is 20 — 4. A similar system is used for marking the hardness and resilience of various kinds of steel, corresponding to typical treatments. The best types of treatment were as follows:

No. 1	No. 2	No. 3
$\Delta = 800$	$\Delta = 750$	$\Delta = 770$
$\varrho = 2$ kgm.	$\varrho = 4$ kgm.	$\varrho = 3$ kgm.

For each type of steel the mark corresponding to each of these typical treatments has been calculated in the following manner: For hardness the mark is lowered from 20 by as many pounds as the difference between the optimum hardness and actual hardness contains tens of units on the Brinell scale (the mark may be increased under the same conditions when the actual hardness exceeds the optimum hardness). *Resilience.* The mark is determined in accordance with the real value of hardness, and then decreased or increased in accordance with the actual value of resilience, one point in the mark corresponding to a difference of 0.5 kgm between the optimum resilience and the actual resilience. For example, a steel of which the actual hardness and resilience for the three typical treatments is as follows:

No. 1	No. 2	No. 3
$\Delta = 780$	$\Delta = 710$	$\Delta = 740$
$\varrho = 2.5$ kgm	$\varrho = 3.5$ kgm	$\varrho = 3$ kgm

will receive for each of these treatments the marks as follows:

No. 1	No. 2	No. 3
$2 - 2 + 1 = 19$	$20 - 4 - 1 = 15$	$20 - 3 + 0 = 17$

The author has further determined the *sensitiveness* of steels to various successive treatment. The steels have been submitted to several temperings one after another, with annealings between each two treatments. The value of hardness after the fifth treatment has been utilized for classifying the steels from the point of view of their ability to withstand these repeated treatments, the steel of which the hardness does not change after five temperings being with the mark 20, which is reduced by as many points as the decrease of hardness contains tens of units on the Brinell scale. A study of different steels from this particular point

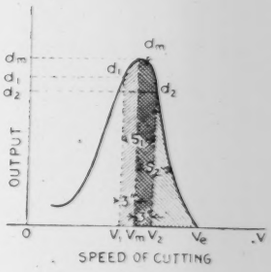


FIG. 7 CHARACTERISTIC CURVE OF OUTPUT OF TOOL STEEL

of view has led to the following conclusions: First, the resilience increases with the number of temperings to which the steel has been submitted; after the fifth treatment, the resilience of certain steels is nearly doubled while in others it increases by one half. Therefore, if by successive temperings tool steels lose a certain amount of their initial hardness, their resilience rises, and, as a result, the efficiency which depends on the magnitudes of these two characteristic values, will vary less than would have been the case otherwise; second, after ten successive temperings with annealings in between *carbon* steels properly so called with the content of carbon in excess of 0.7 per cent, give quite variable results from the point of view of hardness. These steels have hard parts, the hardness of which is comparable to the initial hardness, and soft parts, the hardness of which goes down to 500 and even 400 Brinell units.

Special steels treated in the same way preserve a uniform hardness in all of their parts, but this hardness goes down as the number of treatments increases. The resilience of both carbon steels and special steels slightly decreases after the fifth tempering, but after the tenth tempering its value is still superior to the initial value. This classification (compare above Table 2) shows that the steel which can give the best results on metal working cold is the extra hard chromium steel S_3, hypereutectoid steels C_6, C_7, and C_4, and hard chromium steels S_1 and S_2. Tungsten steels have lower efficiencies. Special nickel chromium steels are not and have not been included in the table, and have practically no sen-

sitiveness with respect to tempering. Their hardness after tempering is much inferior to the hardness of carbon and special alloy steels, but their resilience is much superior to them. Their sensitiveness to successive temperings is very low. Case hardening followed by a tempering at the bottom temperature gives to nickel chromium steel an optimum hardness of about 720 Brinell points, comparable to the hardness of high carbon steel and special alloy steel tempered but not annealed. "Six per cent" nickel steel possesses after tempering a much lower hardness than preceding steels but a far higher resilience (12 kgm as compared with 5 kgm). It has a very high elastic limit.

Tests while hot. The results of these tests show the heat treatment which is likely to give the best efficiency and the curve of output corresponding to the best utilization of the tool. The following methods have been used to classify various steels from the point of view of their hot outputs and efficiency. The efficiency of tool steel in the operations effected while the steel is hot, depends either exclusively or at least to a very large degree on the value of hardness and tenacity at the temperature at which the tool works. The tenacity of carbon steels and special steels is usually at its minimum around 100 deg. cent. (212 deg. fahr.). Its value rises considerably (to above 2000 kg) at a temperature of 150 deg. cent. (302 deg. fahr.). It increases still further as the temperature rises and reaches its maximum value of 4000 to 5000 kg at temperatures between 200 to 250 deg. cent. (392 and 482 deg. fahr.). The hardness of the same steels, which lies at the ordinary temperature between 700 and 800 Brinell units, diminishes at first in a very noticeable manner up to the temperature of 100 deg. cent. (212 deg. fahr.). It is generally in the neighborhood of 650 units at temperatures between 100 and 200 deg. cent. (212 to 392 deg. fahr.), and very rapidly decreases then as the temperature rises. Except in the case of tungsten steels S_4 and S_5, the hardness is below 550 Brinell units at a temperature of 300 deg. cent. (572 deg. fahr.).

The variation in hardness which is the most important characteristic, produces noticeable variations in the efficiency of steels, while corresponding variations of tenacity have much less influence on efficiency. One can therefore consider the variations of $\Delta^2\tau$ as representing in a sufficiently close manner the variations of efficiency at different temperatures. The author has calculated for each kind of steel, the value of the above expression at temperatures of 150, 200 and 250 deg. cent. and with the average values of them obtained the following equation:

$$C_r = \frac{1}{10^8} \cdot \Delta^2\tau$$

which he calls *coefficient of efficiency* and which permits to classify steels from the point of view of efficiency while hot. The author gives a table of coefficients of efficiency for various steels between temperatures of 150 and 250 deg. cent. This table shows that special steels are likely to give better efficiencies than carbon steels properly so called, and that among the latter, hypereutectoid steels will give a higher efficiency. As regards output, the curves of output obtained by means of the Herbert machine permit to gain a basis for the classification of various kinds of steel.

In order to use these curves of output for the classification of steels, it is necessary to bear in mind the characteristic elements of these curves which are as follows: (1) the best speed of cutting v_m which gives the maximum of output; (2) the maximum of output d_m corresponding to the best speed; (3) the width of the curve about this maximum (variations of output for variations of speed cutting are less pronounced as the curve grows wider in this region); (4) the limiting speed of cutting v_e beyond which the steel is not susceptible of any output and which, together with the best speed of cutting, limits the zone of economic speeds. In Fig. 7 assume that d_1 and d_2 be the outputs obtained with a tool steel with velocities of cutting v_1 and v_2 equidistant from a best velocity of cutting v_m (the equidistance being 3 m); these ordinates d_1 and d_2, the axis of velocities of cutting, and the upper part of the curve of output form the limits of the surface S_1, the extension of which characterizes the width of the curve about its maximum. On the other hand the surface S_2 represents the zone of economic speeds of cutting of the steel and its value characterizes the extension of the curve to the right of the maximum and the magnitude of the limit speed. The expression

$$F = \frac{1}{100} v_m (S_1 + S_2)$$

using the characteristic elements of the curve of output of each of the steels gives a method of differentiating them from the point of view of their cutting properties and may be called the *characteristic function of the curve of output.* The steels which are likely to give the best outputs are (with the exception of the tungsten steel S_4 which is at the head of the list) the hypereutectoid steels C_5, C_6, C_7 and the extra hard chromium steel S_3 which, as shown above, also have the best efficiency when working cold.

Taking all three above classifications together, the author establishes a general classification for high carbon and special steels which shows that chromium and tungsten steels generally do not stand well successive heatings and temperings, and that, unless the operations are well conducted, are liable to suffer. High carbon steels (with carbon content in excess of 1.15 per cent) require to be treated with great care, and are generally quite sensitive to tempering; the hardness (as well as resilience, but in a lesser degree) of a large number of steels varied quite noticeably with the temperature of tempering and annealing, and it is absolutely necessary to use in their tempering the best temperature corresponding to the particular use to which they are going to be applied (*type-treatment*). In places where complete equipment for tempering, such as special furnaces, pirometers, etc., is available, chromium, tungsten and high carbon steels are preferably to be used, but where only simpler and cruder equipment is available, hard chromium steel and hypereutectoid carbon steels are preferable.

Power Transmission

Power Transmission Losses and Stresses in Belt and Rope Drives (*Die Übertragungsverluste und die Beanspruchungen der Seil- und Riementriebe,* K. Kutzbach, *Zeits. des Vereines deutscher Ingenieure,* vol. 58, no. 25, p. 1006, June 20, 1914, 6 pp., 8 figs. *te*). The author investigates the losses occurring in transmission of power by rope and belt drives and the stresses occurring in these transmission elements. He explains the distinctive features of the rope and belt drives by the elastic properties of these materials. Their common property of increasing the efficiency with the increase of useful tension, holds as long as the absolute losses remain more or less independent of the useful tension. In

the case of ropes, low elasticity and the unavoidable variation in length, far more than strength, limit their practically permissible tension, and consequently the efficiency of rope drive, which, from a practical standpoint, is not always the deciding argument. The author investigates graphically the action of centrifugal force in the case of belt and rope drives and the nature of what is known as "excess stress," as well as the distribution of stresses while the drive is in operation; by means of tension diagrams he shows why vertical rope drives are so difficult to install and so little reliable unless the ropes used are of particularly great elasticity. But even if such ropes were available, they would not be better than a rope drive having an axial stress of 30 to 40 kg/qcm. Rope drives working at high stresses always provide a stiff transmission, and the softness and elasticity of a leather belt transmission can be obtained in the case of rope drives only when the stresses in the rope are low. If in an installation involving a considerable amount of non-uniform drive or shocks, say an electric motor, a particularly soft transmission is required, nothing better can be devised than a really elastic and long leather belt connecting large masses at both pulleys. In such a case all the irregularities of operation and shocks will be taken up by the spring action of the belt, while in the case of rope it will be the transmission apparatus that will have to take them up. This will result in unpleasant knocking of the loose drums which is entirely avoided when belts are used. As far as efficiency alone is concerned, the steel belt is at the top of all other belts or rope methods of transmission, but owing to its very high coefficient of elasticity and the low influence of the action of its own weight for short distances, it gives a drive which connects the two wheels not elastically, but rigidly.

Steam Engineering

Novelties in the Design of Brown-Boveri-Parsons Turbines (*Neuerungen im Bau Brown, Boveri-Parsons Turbinen. Zeits. für das gesamte Turbinenwesen*, vol. 11, no. 16, June 10, 1914, p. 253, 2 pp., 3 figs. *d*). The article describes the recent development in the design of the Brown, Boveri-Parsons steam turbines. The tendency is towards making the turbine more compact which is facilitated by the new materials of high resistance to stresses which have recently appeared on the market. The general design of the turbine (compare Fig. 8A) has remained unaltered with the following improvements, however: In order to reduce the amount of steam flowing through the dummy piston, the arrangement of equalization has been changed. It has formerly been usual to have one dummy piston at the high-pressure end and another at the low-pressure end, and to lead the "loss" steam from the high pressure and dummy piston direct into the exhaust of the turbine. Now, however, this steam is passed through the hollow shaft into the stage between the intermediate and low-pressures, and is therefore enabled to do the work in the low-pressure stage. By means of a small increase in diameter it proved also possible to obtain a little freer working of the dummy piston. An improvement in the construction of collar thrust bearings has made it recently possible to omit the dummy piston at the low-pressure end entirely and in this way to improve considerably the steam consumption.

In order to utilize fully the steam pressure at various loads on the turbine and avoid uneconomic throttling, the nozzles have been distributed into several groups; the first group, Fig. B, is directly under the action of the main regulating valve *W*, while the following groups, the number of which depends on the size of the engine, are regulated by one to four additional valves operated by oil under pressure. At small loads, only the nozzles regulated by the valve *W* are opened. When the load increases, the pressure behind these nozzles increases also and simultaneously the oil pressure under the piston *Y* increases so that when the steam pressure at the nozzles has approximately reached the boiler

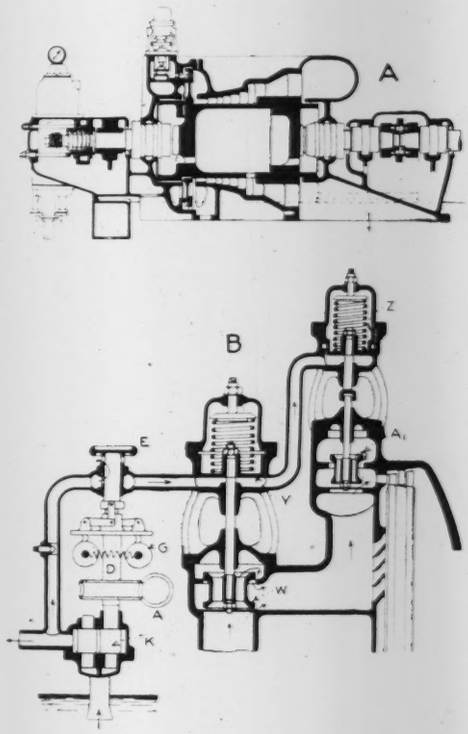


Fig. 8 Brown-Boveri-Parsons Improved Turbine

pressure, a new set of nozzles will be opened, if the turbine is to carry a still greater load. This is done by the rising oil pressure under the piston *Z* of the supplementary valve A_1, the piston *Z* being arranged in such a manner that the valve cannot occupy any intermediate position, but must be either fully opened or fully closed at the moment of the opening and closing of the additional valve. There must be, however, some supplementary regulation of the main valve *W*, if there are several supplementary valves. The springs of the oil piston *Z* must be graduated in such a manner that the next valve will open only after the oil pressure has risen to the required extent; that is, when the steam pressure in front of the valve has reached nearly the level of the boiler pressure. The regulation proper is always carried on by the main regulating valve *W*, which, owing to the peculiar shape of the sleeve, is all the time in an oscillating motion and peculiarly adapted to respond to the slightest variations of the speed of rotation. Further information about the action of this apparatus is promised in a future issue of the paper.

Strength of Materials

COMPRESSION TESTS ON CEMENT CUBES (*Druckversuche mit Betonwürfeln,* Otto Graf, *Armierter Beton,* vol. 7, no. 6, June 1914 (article not finished) (*eA*). The present article gives a compilation of results obtained at the laboratory for testing materials at the Royal Technical High School in Stuttgart from tests on the strength of cement cubes. The tests have been carried out for a number of years and the article gives a fairly complete account of the results obtained. On account of lack of space only the final conclusions will be reported here.

As regards the relation between the size of the body and its compression strength, it was found that cement bodies having a cross section of 480 qcm exhibited a considerably lower compressive strength than cubes with cross section of 50 qcm. It appears that the strength of a cube is a function of its age, and also that the ratio between the size and compressive strength of a cement cube is affected by the amount of water used in the preparation of the cement. Increase in the length of time of mixing produced a slight improvement in strength. As regards the relation between the amount of water used and the compression strength, the tests indicate that the older the test piece the less its strength is affected by the amount of water used. On the other hand, the influence of the amount of water used is but little affected by the cement test piece being kept in dry or moist atmosphere.

ENGINEERING SOCIETIES

FRANKLIN INSTITUTE

Journal, vol. 178, no. 1, July 1914, Philadelphia, Pa.

Locomotive Superheaters and their Performance, C. D. Young (abstract)

An Apparatus for the Spectroscopic Synthesis of Color, Herbert E. Ives and E. J. Brady

The Problem of Motor Gasoline, John Winkler

LOCOMOTIVE SUPERHEATERS AND THEIR PERFORMANCE, C. D. Young (83 pp., 56 figs. *heA*). The article may be divided into two parts; the first containing a historical sketch of the construction of superheaters, and the second, data of tests performed at the Altoona shops of the Pennsylvania Railroad Company. On account of lack of space only the second part of this interesting article is reported here. The data of tests are presented partly in the form of curves and partly as tables. The superheater used for the tests was a Schmidt superheater of the fire-tube type or an altered form of it, consisting of tubes arranged in groups or elements and located in the large flues in the boiler. It was arranged in such a way that the steam from the boiler entered the header in the smoke box, then flowed into one of each of the superheater elements, passing twice through the hot gases which surrounded the element, and then directly to the cylinders. In order to obtain different degrees of superheat without in any way changing the water heating surface of the boiler or the engine conditions, different forms of superheater elements were used with the same superheater header and large flues. The various superheater elements and their sizes are shown in the original article. The locomotive used for all of the superheater tests was a class *K2sa* Pacific type passenger locomotive of the Pennsylvania Railroad Company with brick arch in the firebox. A complete efficiency test of this locomotive, equipped with the standard form of the Schmidt superheater, was made before the special superheater tests were undertaken (the results are given in full in Bulletin No. 18, issued by the Pennsylvania Railroad Company).

The results of tests refer to the following subjects: *Effect of different degrees of superheat,* tests made with small superheaters, superheaters of ¼, ½ and ¾ length. The small superheater tests gave an evaporation of about 31,000 lb. of water per hr., with an indicated horsepower of 1425, while with the same cut-off and an extra length superheater, the evaporation was only about 21,000 lb. for the same indicated horsepower, this effect being caused by the small superheat obtained with the short returns which require a great weight of steam for the power produced. It was found further that the small superheater would evaporate only 70 per

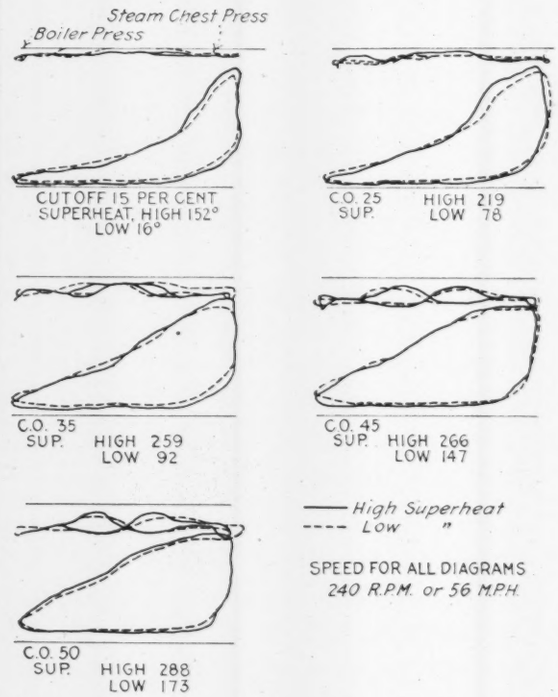


FIG 9 HIGH AND LOW SUPERHEAT INDICATOR DIAGRAMS

cent of what the half-length superheater was capable. The small capacity of this header superheater was brought about by the fact that it did not extend into the large flues in the boiler. As a result of this, the boiler did not steam properly. The draft action was disturbed and holes were made in the fire by the violent agitation of the draft. The small superheater gave a maximum superheat of but 26 deg. The superheaters of ¼, ½ and ¾ length showed a regular increase in superheat produced with the increase in length of superheater. Further, as superheat was increased, the evaporation when running at a short cut-off was decreased; the one half length superheater gave a greater evaporation than was obtained with any other, namely, about 55,000 lb. per hr. It must not be understood, however, that this superheater, which is best for evaporation, gives the maximum horsepower. The extra length shows a higher superheat than standard length, but there might be difficulties in its use where the ends come within a few inches of the fire-box and of the flue. The standard half-return type gives fully

as much superheat. As regards the relation between cut-off and superheat, it appeared that the superheaters ranged in this respect in very nearly the same way as in regard to length of superheater and amount of evaporation, which might be expected since, on account of the constant speed, the evaporation was almost entirely a function of the length of cut-off.

Considering the economy resulting from the superheat, it appeared that at the shorter cut-offs there was a uniform decrease in the water rate with each increase in superheat. As the cut-off was extended, the water rate increased but had a tendency to become more nearly constant with an increase in superheat. A water rate of 24 lb. was obtained with the superheat of about 30 deg., but if the superheat was increased to 220 deg. without a change in cut-off, the water rate was reduced to 16 lb. From the table given in the original article, it appeared that at 15 per cent cut off, at the speed all the tests were made, for every 20 deg. rise in superheat there was a reduction in water rate of 1 lb. per indicated h.p-hr. At 50 per cent cut-off, this changed to a requirement of about 40 deg. rise for the same reduction in water weight. It appeared further that superheat always showed a saving in steam if the cut-off did not exceed 50 per cent. A further diagram shows that every increase in superheat resulted in a saving of coal per h.p-hr.

The article gives also data on temperatures in the boiler tube and superheater flue. It appears that there was a loss in steam pressure as the steam flowed from the boiler through the superheater to the steam chest. The superheater equipped with spiral blades in the tubes showed the largest loss in steam pressure as the steam flowed through the superheater. These blades had a retarding effect and the increasing superheat obtained by their use did not compensate for the loss of power due to the pressure fall. The short returns showed the least drop in pressure while the single-pass superheater showed a little greater drop in pressure. The diagrams for high and low superheat given in Fig. 9 indicated that there was a drop in pressure between the boiler and steam chests of about 8 lb. During the admission to the cylinder the steam having a low superheat showed loss in pressure throughout, but during expansion the pressure for the low superheated steam was higher than for the highly superheated steam. During the return stroke of the piston the steam having a low superheat showed a higher back pressure than the highly superheated steam. This indicated that the highly superheated steam was more fluid or flowed more freely into and out of the cylinder than did the steam of low superheat.

The results of the tests showed conclusively that there was an almost direct relationship between the economy in water and fuel and the degree of superheat. If the superheat at a short cut-off could be obtained as high as that which was obtained for a long cut-off, no doubt more remarkable economies would have been possible in steam per indicated h.p-hr. The other deductions which may be drawn from these tests were summarized by the author as follows:

(a) The standard superheater now in general use is found to give very satisfactory results with a possibility that some of the return portion could be eliminated with no detriment to the superheat obtained, and with an advantage in cost of material.

(b) Too much importance cannot be attached to the length of superheater; it must extend as far toward the fire as practicable limitations will allow, considering the life of the elements in the hot gases.

(c) There is an advantage in the return portion of the superheater, but this part may be shortened; to what extent has not yet been finally determined.

(d) As the superheat is reduced, the evaporation of the boiler is increased within certain limits; in other words, a boiler without superheater shows a larger maximum evaporation than one with a superheater. The power of the locomotive, however, does not increase with the greater weight of steam produced; on the contrary, the power is reduced with the reduction in superheat.

(e) Within the limitations of these tests, the highest superheat does not result in the lowest water rate; this is on account of the fact that to obtain the highest superheat the locomotive may be run at an excessively long cut-off, the long cut-off increasing the water rate to a greater extent than is compensated for by the increase in superheat.

INSTITUTE OF MARINE ENGINEERS

Transactions, Session 1914-1915, June 1914. Stratford.
Wood Charcoal, its Manufacture and Uses, W. D. Ashton Bost (abstracted).
Board of Trade Report on Explosion from a Boiler Stop Valve Chest.

Wood Charcoal, its Manufacture and Uses, W. D. Ashton Bost (33 p. *gp*). The article discusses mainly the uses of wood charcoal. The author states that "in America the output of charcoal iron is enormous, owing to the vast amount of cheap wood and the furnaces carbonizing it for themselves and recovering the products." Speaking of the use of charcoal for insulation, especially on ships, the author discusses the possible fire danger.

As regards the method of extinguishing flake charcoal, the author states that it is done by freely exposing it to the air; it was formerly supposed to be extinguished by absorbing oxygen in the process. This, however, is not correct, because, although flake charcoal does absorb all the oxygen it wants, this has nothing to do with the cooling which is effected by allowing it to give off all its heat while being tossed about. By exposing each particle to the air, the temperature of the coal is lowered after a certain number of such exposures. While lump wood charcoal takes 24 hr. to cool with exclusion of air, flake charcoal takes 10 min. when exposed to the air. In the well known tests of Dr. Rosenhain, it was found that the conditions necessary for firing charcoal were such as could not be found at sea except in the case of fire outside the charcoal setting it on fire. The only exception possible is the presence of sulphur dioxide. In Dr. Rosenhain's first experiment, the conditions were more severe than could occur in actual practice, for the charcoal was put loosely into a perforated box, surrounded on all sides by 3 in. of air free to move, whereas in practice the charcoal has air-tight casing. Even under these conditions the temperature was raised to 370 deg. cent. or nearly four times the temperature of boiling water without ignition taking place. It might however be said that while charcoal in the insulation is not liable to spontaneous combustion, yet it might help to propagate a fire.

The following figures from the Board of Trade reports on fires in British steamers of 100 tons and upwards for twelve

years, show that in proportion to the number of ships fitted with charcoal and silicate cotton respectively, there have been more fires in the latter than in the former. If instead of making the comparison between charcoal and silicate cotton, it is made between combustible and uncombustible insulating material, it would be found that in proportion to their numbers there have been more fires in the latter than in the former. It is further proved that a fire on a ship with combustible material is generally less serious in character than on one fitted with incombustible material, which is a somewhat startling fact.

SOCIETY OF ENGINEERS

THE UTILIZATION OF SOLAR ENERGY, A. S. E. Ackermann. (Abstracted from report published in *The Electrician*, April 17, 1914.) The paper was read before the Society of Engineers on April 6, 1914, and gave some hitherto unpublished data on the sun power plant as well as data on tests of the absorbers used in this plant. The latest pattern of the absorber gave a maximum thermal efficiency of no less than 40.7 per cent and a maximum output of steam of 1442 lb. per hr. at a pressure of 15.8 lb. per sq. in. absolute. This absorber consists of five sections, each 205 ft. long, 13 ft. 5 in. wide between the edges of the mirrors. The cross-section of each of the five sections is parabolic and the mirror portion may be described as five large parabolic channels. The sections are placed with their major axis north and south. To receive the morning sun they are heeled over to the east and move automatically very slowly from that position to the west so as to follow the sun. This automatic movement is controlled by a small and simple thermostat, consisting of three fingers, each made of a thin plate of brass underneath and a plate of vulcanite on top. The principle of working this thermostat is that two fingers are in the shade and the third in the sunshine. Should one of the outer fingers get off from the shade it is rapidly heated up by the sun, bends down, closes an electric circuit and starts a mechanism which moves the mirror. From the results of tests of various types of absorbers the author has derived a formula by means of which it is easy to calculate for a given type and size of absorber the total output of steam per hour, when three things are known: the time of day, the steam pressure and the humidity (humidity adversely affects the quantity of solar radiation arriving at the earth's solid surface). The author shows further that in the case of such low-pressure boilers, the high thermal efficiency is not necessary since, up to a certain point, the higher the steam pressure the more economical the working, although the thermal efficiency is then lower.

THE ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Proceedings, vol. 30, no. 1, February 1914. Pittsburg, Pa.

Discussion of Operating experiences with Steam Regenerators (abstracted)

Crucible Steel, George H. Neilson

TESTS OF STEAM REGENERATORS AND LOW PRESSURE TURBINES, FRANK E. LEAHY (39 pp., 6 *figs. e*). In a previous paper before the same Society, Mr. F. G. Gasche discussed the theory of steam accumulative and regenerative processes which prompted several engineers in the Western Pennsylvania district to make extensive tests with steam regenerators. Mr. Leahy made tests on a regenerative system located between a blooming mill and a slabbing mill in front of a low-pressure turbine station, consisting of three American steam regenerators connected in parallel and operating as a unit. Each regenerator consists of two steel tanks, one above the other, the lower being designated as the expansion chamber and the upper as the regenerative chamber. The operation of the regenerative system is as follows: the exhaust steam enters the lower tank and in passing into the spray-box strikes a vane, turning it through a certain angle, depending on the quantity of steam flowing. This movement is transmitted to the regulating water valve which admits the water to the spray-box. The greater the quantity of steam flowing, the greater the angle through which the vane turns and as a consequence the admission of water through the valve. The steam and water meet in the spray-box and the mixture passes through an ejection pipe into the upper tank, the water absorbing the heat from the steam on the way. In this manner the heat is stored in the upper tank and becomes available for use when required. If at any time the pressure in the top tank drops to sixteen lb. absolute, due to decrease in the supply of exhaust steam, the live steam reducing valve is automatically opened and admits steam to the lower tank, closing as soon as the pressure in the top tank increases to eighteen lb. absolute. If at any time there is such a surplus of exhaust steam that the pressure in the top tank exceeds nineteen lb. absolute, the relief valve opens, discharging the excess steam to the atmosphere. In order better to control the conditions of operation in the tests, live steam was used throttled through a reducing valve. The observations during the tests were taken as follows: The average temperature of the water in the regenerator by thermometers placed at various places in the tank; steam temperature by a thermometer placed in the top of the regenerator tank; pressure in the top and bottom tanks by mercury columns; height of water on both ends of the regenerative tanks by graduated water gage glasses.

The author presents the results of his tests in the form of tables (see Table 3). In addition to the tests of the regenerative equipment, tests of the turbo-generators were also made. The low-pressure turbine station consists of one Curtis low-pressure turbo-generator, one General Electric motor-generator set, one small General Electric turbo-generator, with d. c. for excitation, switchboard and a Weiss dry air pump. The low-pressure turbine is a Curtis horizontal, three-stage impulse type rated at 3000 kw., 1500 r.p.m., form *E*, designed to run condensing and deliver its rated capacity with an initial pressure of 16 lb. absolute. The turbine exhausts into a Weiss barometric counter current condenser of self supporting type and a rated capacity of condensing 150,000 lb. of steam per hour. The turbine tests were run to determine the steam consumption of the turbine at various loads. The net results obtained by the installation of the low-pressure turbine and regenerators were as follows:

First: An increase of 57.5 per cent in the rated electrical capacity of the plant.

Second: The back pressures, in pounds per square inch, on the blooming and slabbing engines were as follows:

	Operating Alone		Operating Together		Before Turbine Installation	
Engines	Average	Maximum	Average	Maximum	Average	Maximum
Blooming Mill..	3.77	10.00	7.35	10.00	1.50	5.30
Slabbing Mill ..	5.04	10.06	7.82	11.00	1.10	6.20

Third: The load on the turbine is such that the steam consumption of the turbine is practically constant. When only the blooming engine is operating, the supply of exhaust steam, which is approximately 76,000 lb. per hour, is insufficient to meet the demands of the turbine and in order to provide this deficiency, the live steam valve is open about 10.5 minutes per hour. When only the slabbing mill engines are operating, live steam is admitted to the turbine about 2.6 minutes per hour, exhaust steam from these engines being approximately 100,000 lb. per hour. In either of the above cases it is very seldom that any exhaust steam escapes to the atmosphere. When both mills are operating at the same time, the exhaust steam is much in excess of the demand, and the relief valves are open about 18.9 minutes per hour, discharging the excess steam to the atmosphere.

Operating difficulties: When the low-pressure turbine and regenerators were first put into service a good deal of trouble was experienced with the reducing valves. This being a straight low pressure turbine it is imperative that the reducing valves be absolutely reliable and positive in their performance. The first valve used was a 12 in. Foster reducing valve designed to open at 15 lb. and close at 15.5 lb. absolute pressure, but it proved not to be well adapted to this kind of service and better results were later obtained by the use of a balanced piston valve which is positive in its action, being controlled directly by the pressure in the regenerators. This valve has been in operation since July 1912 and has given complete satisfaction. Another source of trouble was due to the imperfection in the design of the pilot valve which operated the water mixing valve. It would find a position of admission and exit that would give to the piston of the operating cylinder a violent reciprocating motion, either breaking the valve steam or causing the valve to sit hard enough to break the body of it. A change in the design of the piston and ports was made which eliminated this trouble. The article contains very complete data of the tests.

Experiments with a Small Steam Regenerator, C. L. W. Trinks (6 pp., 4 figs. *e*). The experiments made by the author included tests on an experimental regenerator made of 20 in. pipe and experiments on absorption of jets of steam in a specially constructed glass vessel. The author found that the results obtained from the former were not applicable to apparatus of commercial size. In the experiments with the glass container, conditions were maintained such that the temperature, pressure and water level were kept constant. Steam was added in such quantities that all of it was just absorbed at the surface of the water, thus representing the limit of total steam absorption for the given discharge orifice, temperature difference and depth of immersion. At first a single jet of steam was used, and its shape proved to be different from what might have been expected. Instead of there being a number of bubbles rising through the water, the jet expanded to at least four times the size of the pipe opening and looked very much like an unsteady flickering flame, the top of which was darting hithr and thither (Fig. 10A). Spreading of the steam jet was probably due to the resistance which it found against the water in trying to rise. A small box was next used resembling a section of a regenerator element. It was discovered that the steam coming out of the lateral holes spread to such an extent that the steam jets interfered with each other. It was also discovered that the kinetic energy of the flow of steam was excessively large as compared with the discharge capacity of the bottom openings. A special baffle was then provided to produce induced circulation. The left hand part of Fig. B shows approximately the appearance of the steam jets essentially different from that shown in the catalogue of the Rateau Regenerator Company. Fig. C shows that complete steam absorption with small temperature difference necessitates a very slow rate of flow of steam and discharge through the upper row of holes only. If complete absorption of steam and discharge through several rows of holes is wanted, the temperature difference between the steam and water must be quite excessive. The author gives the following brief calculation; with permissible temperature difference and for complete absorption of steam, a horizontal length of absorbing surface of about three miles will be necessary for an ordinary 55 x 60 reversing engine doing medium, heavy work at 60 r.p.m. This figure is based on 15 deg. fahr. temperature difference and a 4-in. depth of immersion. If three regenerators were used, each with four absorbing surfaces, and if the depth of immersion be increased to ten inches, then the length of the regenerator could be reduced to 500 ft. This appears to show that regenerators as designed now cannot absorb all of the steam which comes from a reversing mill engine unless the temperature difference is excessive.

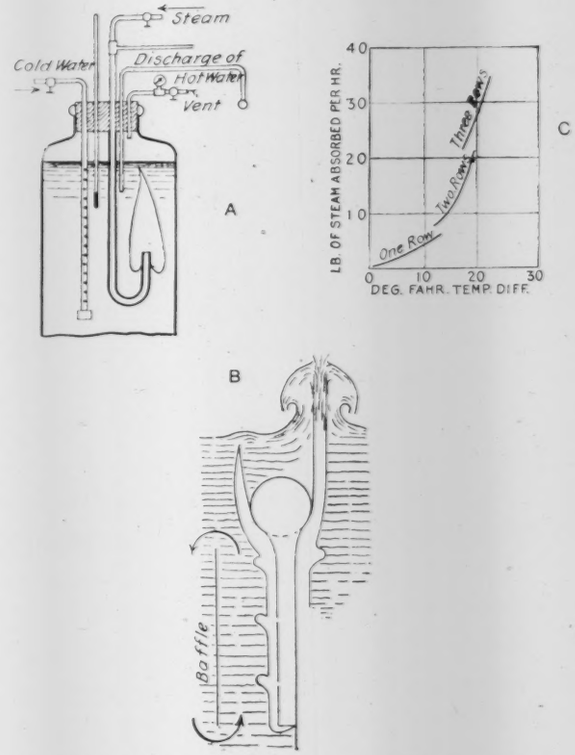


Fig. 10 A and B, Spread of Jet in Small Steam Regenerators; C, Steam Absorption in Regenerators

The author believes that all absorption regenerators would have to be redesigned in the shape of multiple flat boxes with considerably less depth of immersion and only one row of holes, which would make them too costly for commercial

TABLE 3 SUMMARY OF TESTS MADE ON REGENERATOR (NO. 2) AT TURBINE STATION REGENERATIVE PERIOD

Test No.	Tank No.	V Cu. Ft.	W Lb.	m Lb.	t_3 Deg. F.	t_2 Deg. F.	t_1 Deg. F.	θ (t_3 to t_2) Sec.	θ Sec.	Q Actual Heat Storage	Q Theoretical Heat Capacity	Efficiency Per Cent
1	2	896	93,909	567	222.3	216.0	205.0	1.00	88.2	1,045,800	1,637,280	63.8
2	2	991	88,200	567	225.1	216.2	206.5	1.85	77.3	871,257	1,656,237	52.6
3	2	991	88,178	567	227.1	219.3	206.3	2.08	101.8	1,164,132	1,851,920	62.8
4	2	893	94,374	567	225.0	214.2	195.2	3.21	162.8	1,814,245	2,833,384	64.0
5	2	970	89,363	567	227.2	219.8	210.3	1.89	77.4	863,653	1,524,939	56.6
6	2	979	89,292	567	225.3	212.8	195.0	1.87	150.0	1,612,865	2,729,013	59.1

V volume of receiver spaces, cu. ft.; W weight of heat absorbing water lb.; m pounds of steam per minute from the regenerator; t_3 temperature of steam entering the regenerator, deg. fahr.; t_2 final temperature of absorbing water, deg. fahr.; t_1 initial temperature of absorbing water, deg. fahr.; θ (t_3 to t_2) time in seconds for receiver expansion from t_3 to t_2; θ (t_3 to t_1) time in seconds for regenerator expansion from t_3 to t_1.

purposes. Further experiments have shown that with the comparatively small quantity of steam passing unabsorbed, the rate of steam absorption could be vastly increased. There is, therefore, no well defined limit to the steam absorption; with increased flow more is absorbed, but the water is lifted so high and the steam passing through entrains so much water that the operation of the turbine becomes dangerous. A considerable amount of interesting material which cannot be abstracted on account of lack of space is contained in the discussion which followed the presentation of these papers.

NOTES ON SPECIFICATIONS FOR REGENERATORS, O. P. HOOD (7 pp., 2 figs., *ep*). As a result of some experience in testing a regenerator installation, the author discusses the wording of a contract for this class of apparatus. One of the problems in establishing the specifications for regenerators is that of defining its capacity. A definition, "the capacity of the regenerator plant shall be sufficient to handle the maximum hourly rate of delivery (of exhaust steam) to the best practical advantage," is entirely too indefinite to insure a device that would use a fair proportion of the waste product and at the same time not interfere with the functions of the engine. A better statement would be, "the regenerator will be of sufficient size to operate a turbine unit of the given capacity for a period of five minutes after the supply of steam is shut off," but some provision in such a case has to be made as to how long previous to the shut off the supply of steam shall be maintained. A statement of the following kind "provided the supply has been maintained for a sufficient time to provide as many heat units as the containing water will absorb at the operating pressure" is rather unfair to the buyer of the apparatus since whether the device is efficient in absorbing heat or not, the wording demands that steam shall be supplied until the absorption is complete. In the contract which the author had especially in view, it was further stipulated that "an automatic release valve will be provided to allow a free escape of the steam when the pressure exceeds one pound above the present exhaust pressure." It is evidently to the advantage of the regenerator to have as wide a range of pressure as possible. Running the pressure below an atmosphere on a hoisting engine may be objectionable and the lower regenerator pressure was therefore limited approximately to atmospheric pressure. The superior pressure allowed on the regenerator adds to the back pressure on the engine and this addition increases its normal steam consumption and it is between these narrow limits of pressure that the regenerator must run. With increasing back pressure there comes a condition when the saving at the exhaust end of the operation is more than offset by the cost of the added steam needed by the main engine and the added auxiliaries. This is one of the reasons why some plants of this kind, although returning a product from exhaust steam, are unable to drop any boiler capacity as a result of the installation. In testing the plant it was found that the apparently simple condition of the contract that there should be "a free escape of steam when the pressure exceeds one pound above the present exhaust pressure" proved to be far from simple in determination since it made it necessary to determine what the old back pressure was. As the author states, there may be a very honest difference of opinion as to the meaning of the phrase "back pressure" and also several poor ways of determining what it is. Some of these poor ways the author describes. The most satisfactory method of determining the back pressure would be to take continuous indicator diagrams of the open type, using a light spring arranged with a positive stop so that pressures beyond the range of the spring would not injure it. The average back pressure for each stroke of the cycle could then be plotted as an ordinate with the number of the stroke as a base, thus giving a curve representing the many back pressures through the cycle. Such curves obtained under different conditions would be comparable and the pressure range allowed between them could be a definite matter of contract. This method, however, requires special indicators which are by no means common. It would, therefore, seem to be desirable that in specifications for regenerator installations the method of determining the back pressure from the engines should be a part of the contract as well as the allowed addition of pressure imposed by the regenerator. It is also desirable when applied to the exhaust of a hoist or similar engine, that the regenerator pressure be automatically adjusted according to the load on the turbine, if this is a variable. Although great savings can be made by the use of regenerators attached to hoisting engines, it only takes small additions of back pressure in connection with regenerators of insufficient capacity to change an apparent saving at the e haust into an actual loss at the coal pile.

FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

In the first section, on Aeronautics, will be found data of tests concerning the action of wind on a plane of an aeroplane under dynamic conditions, that is, produced by a blast of which the direction and intensity vary rapidly. In the next section, on Fuels and Firing, are reported data on a German smokeless boiler furnace, and on peat testing. It appears, among other things, from this article that serious attention is being paid to the development, on a strictly scientific basis, of the peat industry in Europe and that promising progress in this direction has been already made. The section on Gas Engineering is closely connected, in some of its features, with that on Fuels. Rummel, in the Journal of the German Society of Engineers, discusses the use of gas in metallurgical plants where it is obtained as a by-product of the operation of blast furnaces and coke-ovens, and, after a thorough consideration of all conditions, comes to the conclusion that the least economical method of consuming the gas is by burning it under boilers, notwithstanding the fact that, as the author states, there are many cases in these plants where steam drive is still the best.

A number of interesting papers are abstracted from the report of the last meeting of the French Gas Technical Society, such as on storage of coal under water; on a new construction of a centrifugal tar separator; on an apparently anomalous phenomenon in the purification of gas by iron oxide; on comburimeters; corrosion of cast iron piping; safety valves for gas meters, and improved formula for the calculation of gas conduits.

From a description of a hydro-electric installation in French Northern Africa are taken data on the Minetti speed governor used in connection with large Francis water wheels. In the next section, Internal Combustion Engineering, are described a number of cooling devices used on internal combustion engines of various makes, as well as a novel construction of steel cylinders. The latter presents a good deal of interest to the American makers of automobile and, perhaps still more, of aeroplane engines, as a steel cylinder, while as reliable as a cast iron one, is at least half the weight of the latter.

In a former issue was described a chain pump of novel construction invented by a French engineer, Bessonet-Favre. It appears that it has been since introduced commercially, and in the present issue we are able to present some data on output and power consumption of these pumps. We are also able to present in this issue data of tests of a Wefer gas fired furnace which has been described in detail in a former issue; the plant, with this type of furnace, has shown a total efficiency of 84.6 per cent.

A brief abstract of the article of Professor Mérigeault on the theory of the Tesla turbine gives data on possible improvements in this type of apparatus, while the next article presents information on the actual conditions of operation of the apparatus which has become lately known under the name of ejectair (first described in the English language in an abstract in the Foreign Review). In the section on Miscellanea will be found data on tests of a mixture of mineral oil and oildag, showing that the presence of the latter material insures a saving in lubricant.

New specifications published by the Association of American Steel Manufacturers are given covering structural and boiler steel, concrete reinforcement bars rolled from billets, and rail steel concrete reinforcement bars. From a paper before the Engineering Association of the South is taken an abstract concerning the Nashville Smoke Ordinance, one of the features of which is that it permits a rather large amount of smoking. Interesting data on the relative thermal efficiencies of steam and producer gas plants will be found in the abstract of R. H. Fernald's paper before the Franklin Institute on Producer Gas from Low Grade Fuels, while a new development in surface combustion boilers, and data of tests of this type of steam generators are described in a paper on the Bonecourt Boiler published by the Institution of Electrical Enginers (London).

W. A. Converse, in a paper before the Railway Club of Pittsburg, considers some ill effects of boiler feed waters from the point of view of the analytical chemist, and throws a good deal of light on some phenomena which cannot be said to be generally well understood, such as, e.g., the relation between presence of scale and corrosion.

Other abstracts refer to the flow of metals under large constant stresses.

FOREIGN REVIEW

Aeronautics

Action of a Rapidly Varying Wind on a Wing of an Aeroplane (*Effet exercé sur une aile par un vent rapidement variable*, Professor A. Lafay, *La Technique moderne*, vol. 8, no. 9, p. 329, May 1, 1914, 3pp., 4 figs. *c.1*). Tests made on models of aeroplane wings or on actual supporting planes are as a rule exclusively static and the blast of air produced by the blower and used for the test is maintained in a permanent state during the duration of each test. In this case, an attempt was made to study the same cases under dynamic conditions, that is, to investigate the variable stresses produced by a blast, the direction and intensity of which vary rapidly. For this purpose, a special aerodynamometer has been constructed in which very feeble elastic deformations are used to balance the force applied. The latter can be evaluated by means of optical amplification. With this apparatus, it has been found that when the wind jumps at an amplitude of twenty degrees in less than a 0.1 second, the stress exerted at any instance differs not more than by one tenth from that which corresponds to a permanent state of operation, with the same intensity and direction of blast as prevails at that instant. If one considers the relative motion of the flying element with respect to the air, it follows from this that one may deduce from suitably arranged static tests, the data necessary for the calculation of the stresses produced in the apparatus under given stresses such for example as those which arise when an air-ship straightens rapidly after a jump or during its entrance into an ascending or descending current of air.

Fuels and Firing

Smokeless Boiler Furnace (*Eine rauchlose Kesselfeuerung*, v. Pasinski. *Rauch und Staub*, vol. 4, no. 9, p. 137, June 1914. 3 pp., 2 figs. *de*). The article describes what is claimed to be an absolutely smokeless boiler furnace which in addition is very economical with respect to fuel consumption under various conditions including overloads. This is the Gartner furnace, shown in Fig. 1A. It has neither special stoking apparatus nor complicated mechanism for regulating the firing. The system represents a type of extended furnace with a trough grate, the coal falling through an inclined shaft from laterally located bunkers onto the grate trough. It undergoes, at the edge of the trough, a preliminary gasification, and is then perfectly gasified by sliding down towards the middle of the grate. Over the grate at a sufficient height and directed towards the boiler, is placed an arch structure; as a result there is a large fire chamber which permits not only the free development of the flame of coal rich in volatile matter but also facilitates combustion through the heat radiated from the arch. However favorable these conditions may be for good consumption, there must be also a liberal admission of preheated air of combustion, and this is effected by making the air enter the wide passages (Fig. B) over the arch of the fire chamber where the air is preheated and reaches the vertical passages of the front (under the grate) while it is quite hot.

In order to make this firing as adaptable as possible to various conditions of operation, a sidestrip of the grate is provided with a separate air admission which may be shut off by a valve shown in Fig. A, and in this way it is possible to vary the active grate area of 1.8 qm (19.3 sq. ft.) without interfering with the process of combustion, by about twice 0.5 qm or 5.3 sq. ft. This side section of the grate having its separate air admission, can be operated also on compressed air which gives a further possibility of overloading the furnace and makes it particularly adaptable for meeting practical requirements. When it is desirable to burn coals very rich in volatile matter, the side arches are provided with double air admission, which may be also cut off by means of a valve. Several tests have been carried out and it was found that as a rule the furnace operated absolutely without any smoke except when it was being cleaned. The author claims also that the saving in coal as compared with the former horizontal grate installation amounted to as high as 29 per cent.

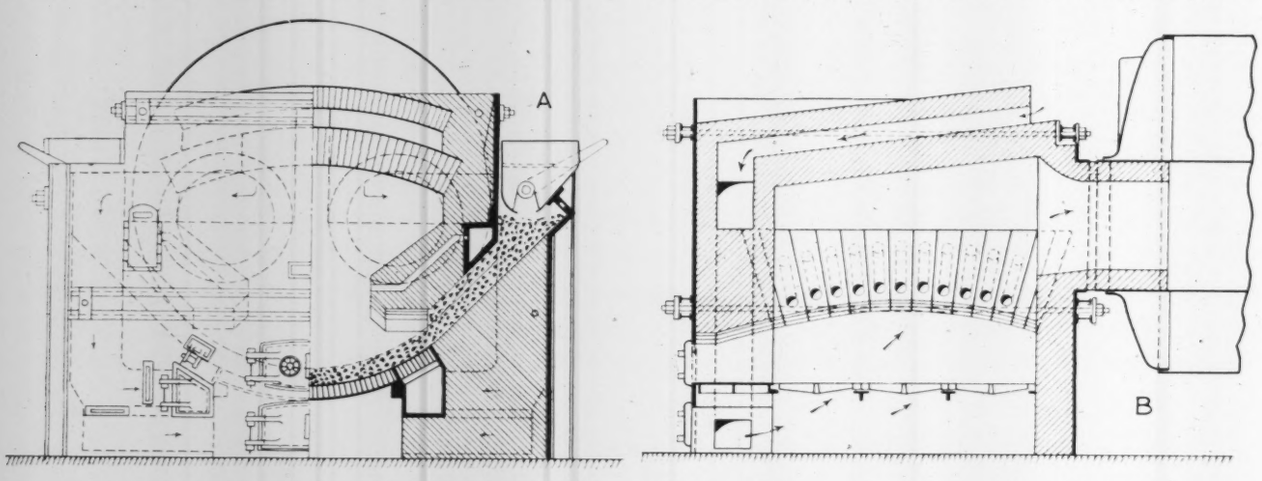


Fig. 1 Gartner Smokeless Boiler Furnace

Contributions Towards the Construction of Scientific and Technical Foundations of the Peat Fuel Industry (*Beiträge zum Aufbau der wissenschaftlich-technischen Grundlagen für die Brenntorfindustrie*, Professor C. Blacher and W. Duglas. *Feuerungstechnik*, vol. 2, no. 19, p. 321, July 1, 1914, article not finished. *et*). The authors present the first report of the laboratory of chemical technology of the Technical High School in Riga (Russia) on the subject of the establishment of scientific and technical foundations for the peat fuel industry. This is a subject of considerable importance in view of the lack of data for the determination of the peat value of bogs. Hitherto, some of the best classificators, such as Walgrens, limited themselves to such expressions as "very good," "bad," "very pure," "very impure," etc., without, however, giving a precise basis for the determination of the fuel value of the material and it is just with respect to the determination of the ability to form peat that an exact method of classification is very desirable. The authors have tried to derive such a method on the basis of the solubility of the humus substances in a solution of caustic potash and the determination of that part which remains insoluble in this reagent. This method would, however, not be convenient on account of the long time taken in the filtration of the caustic potash and the formation of the deposit, as well as on account of the fact that air-dried filters must be necessarily used. It was, therefore, found to be more convenient to use the colorimetric methods and to determine the color of the solution obtained by soaking the peat in a solution of caustic potash. The value, with respect to peat formation, was expressed by the percentage of humus acids or humus substances. In this case by 100 per cent was denoted a solution of the humus substances which after extraction by caustic potash solution and by hydrochloric acid appeared as speck peat. When both methods, the quantative and the colorimetric were compared, it was found that substances soluble in caustic potash gave different values, which would indicate that the caustic potash solution dissolved, in addition to coloring substances, a considerable amount of non-coloring substances, and it is yet a difficult

question to say whether these latter non-coloring substances have any value in the formation of peat fuel. The adaptability of the colorimetric method for the estimation or humus content of peat, for the purpose of determinating fuel value, is an open question until it has been determined which substances give strength to peat formation, that is, which of the irreversible colloids soluble in water give to peat the gel similar to that found in the constitution of coal.

Since, however, the final purpose of the investigation is to determine the amount of peat formed from a given extraction, it is, for that particular purpose, actually indifferent where the percentage value obtained represents actual contents of the important heat substances or gives purely empirical values representing an increase of these substances during the process of peat formation. What is necessary, is to obtain some process which under similar circumstances, would always give similar values. After numerous tests, the following process has been worked out: 0.2 g. of water-free peat were covered with 50 cu. cm. of water to which were added 3 cu. cm. of a 50 per cent potassium solution. The whole boiled for an hour and the water level maintained by additions of fresh water. This was cooled and poured into a graduated glass, filled up to 100 cu. cm. and poured directly into a filter of 1815 cm. Out of the filtrate so obtained, 20 cu. cm. and in case of very dark liquid 10 cu. cm. were poured into a 250 cu. cm. vessel filled with water. The solutions so obtained which were all of quite different colors were then compared first with one another and then with the standard solution in order to obtain the percentages showing the contents of humus substances in the peat. The colorimetric determination has been done in a Wolf colorimeter. In the course of these tests, it proved possible to determine the degree of peat formation in various parts of a bog and it was found that as a rule a more complete peat formation was found in the deeper parts of the bog where the layer was darker in color, while elsewhere the layer containing large amounts of ash was poorer in humus. During these tests, it was found that the color of alkaline humus solutions was not permanent and on this account investigators resorted to the Russian standard solution used for the analysis of sewage waters, and prepared in the following manner: 10 g of $Fe\,Cl_3$ and 2.5 g of $Co\,SO_4\,7\,H_2O$ together with 10 cu. cm. of concentrated hydrochloric acid were dissolved in a liter of water and 100 cu. cm. of this solution passed into a vessel of the Wolf colorimeter. In the other vessel was placed the solution the value of which was investigated and the column of liquid was reduced until its color corresponded to that of the 100 cu. cm. standard solution. The authors attempt to express the factor of climate numerically and further proceed to a brief consideration of the use of peat as a domestic fuel. (This Article is not Finished)

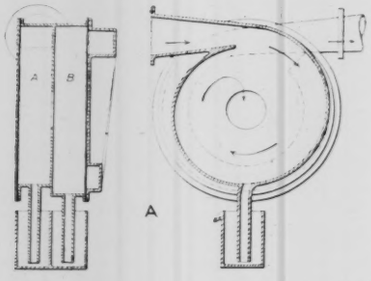
Gas Engineering

THE GAS SYSTEM OF METALLURGICAL PLANTS (*Die Gaswirtschaft auf Eisenhüttenwerken*, A. Rummel, *Zeits. des Vereines deutscher Ingenieure*, vol. 58, nos. 29 and 30, pp. 1153 and 1216, July 18 and 25, 1914, 13 pp. *gp*). The present article investigates what the author calls a gas system of a metallurgical plant, that is the methods of production and utilization of gas obtained in connection with the various primary operations of the plant. It is to a considerable extent of descriptive nature and naturally has reference almost exclusively to German conditions. In the main, the author points out the great development of the utilization of gas in metallurgical plants which has taken place of late. It is very difficult in many cases to determine what is the most economical way of utilizing the gas obtained and each particular case in every work has to be determined in connection with the local conditions existing therein. It is a good plan to consider for this purpose each coke-oven plant or blast furnace as an independent manufacturer striving to sell his gas, even though a by-product, at the best price obtainable. On this basis, a system may be developed for establishing the values at which the gas may become available for different purposes, the prices of the gas thus determined not being necessarily the same in each case. This method of considering the gas producing sections of the plant as private and independent enterprises, is both convenient and productive of good results. The different users of gas in the plant can pay for the gas a price only high enough to enable them to work with it at rates not more expensive than if they were using some other fuel available, for example, coal. The author makes his comparison mainly, therefore, on the basis of a comparison of the cost of 1000 calories in good coal and a similar amount of heat units in gas. In so far as examples taken from actual practice permit of drawing conclusions as to general rules, it appears that in the normal case it is the most economical system to consume the gases produced by blast furnaces, in the power-house of the plant; in the first place for producing the blast, in the second, for current generation, and, finally, for driving the gas blowers of the steel mills. Next comes the use of gas as fuel in the steel mills and rolling mills, as well as for the auxiliary plants such as tempering, heating, and so on. It is only when there is absolutely no other way of utilizing gas that it may be burned under boilers which appears to be by far the least economical methods of its utilization. The coke-oven gases can best be utilized for lighting purposes, next, in gas engines, then in open hearth furnaces, and finally, in the least economical manner, under boilers. With these conditions in view, it appears that in the metallurgical plant the gas engine is substantially superior to the steam turbine, no matter how the steam for the turbine is generated, that is, whether gas fired or coal fired boilers. It is not meant of course that steam is not to be considered as a prime mover for metallurgical plants. The author points out where the steam can be used with advantage and what disadvantages there are in its use. Exhaust steam turbines have not proved successful in metallurgical plants, and the main consumer of steam is found to be the rolling mill whose steam requirements vary with great rapidity and with extreme irregularity. This produces an extremely economical operation on exhaust steam turbines, even with large steam receivers. The double pressure turbine on the other hand would be well adopted mechanically, but has too high an initial cost. On the other hand, the steam turbine in a power plant has the advantage of being able to take large peak loads. The author recommends therefore to use the excess of gas, between the actual gas production and the requirements of the gas driven apparatus in the plant, as fuel under boilers which should be equipped in such a manner as to be able to utilize either coal or gas indifferently. The steam produced in such a manner can be very widely utilized and as shown above, there are many cases where steam machinery properly selected is

quite suitable to metallurgical work. The author, after investigating the proper methods of determining the price of a kilowatt, comes to the conclusion that in many cases, steam is preferable for heavy rolling mill drives.

Forty-First Congress of the (French) Gas Technical Society (*XLI-e Congrès de la Société Technique du Gaz*, *Le Génie Civil*, vol. 45, nos. 10 and 11, pp. 192 and 217, July 4 and 11, 1914, 6 pp., 5 figs. *gde*). The forty-first Congress of the Gas Technical Society of France was held in Paris in June 1914, the regular practice being to hold the Congress one year in Paris and the next year in one of the larger provincial cities. A number of interesting papers have been presented. Rolland d'Estape reported his experiments on the behavior of coal previously stored under water in storage bins and in furnaces. The experiments were carried out with English coal stored in a reinforced concrete cylindrical silo 10 m. (32.8 ft.) high and 4000 cu. m. (141250 cu. ft.) capacity containing about 3200 metric tons (3520 short tons) of coal. The entire structure was above the ground in such a manner that both the water and the coal could be drawn out by gravity. Preliminary experiments have shown that (1), coal kept at a certain depth absorbs only quite negligible quantities of water, and (2), that the quantity of water retained by adherence is proportional to the fineness of the coal (15 to 20 per cent with fine coal and 1.5 per cent in the case of lumps 35 to 50 mm., or 1.4 to 2 in. in size). The coal cannot be dried by simply letting the water run off. It was found that, when special valves are opened, the water contained in the silo runs out in ten and a half hours but drippage continues to flow at the rate of about 30 liters (7.9 gal.) per minute for the first hour and at the rate of ½ liter (0.13 gal.) per minute after fourteen days. The silo was filled up to two-thirds of its height with run-of-the-mine coal, containing 40 per cent of breeze, and in the upper third with three separate lots; run-of-the-mine, lump coal, and run-of-the-mine cleared of dust. Sample quantities of 20 tons each were taken from each of the three lots of coal. The run-of-the-mine coal which contained 9.8 per cent of water when coming out from the silo three days later contained only 6.2 per cent when it reached the distilling rooms, while in the large lumps humidity has gone down 3.6 and even 2.8 per cent. The 600 tons of coal distilled during these experiments have not caused any appreciable fall in the temperature of the furnaces. Calculation shows that vaporization of 6 kg. of water per 100 kg. of coal ought to increase by about 4.5 per cent the combustion of fuel. Since the coal stayed in the silo for only a short time no difference was found in either the quantity or quality of the gas obtained with dry or wet coal.

Mazeran described a *centrifugal tar separator* having no movable parts, provided with two cells, and based on the same principle as the so-called cyclone apparatus. If one imparts to raw gas a rotary motion in a cylindrical space into which it is admitted tangentially with a large fall of pressure, the action of the centrifugal force brings about the separation of tarry particle which enlarge by hitting one another, and are finally projected on to the periphery, owing to the difference of density between the condensed tar and gas. The growth of the tar particles occurs in the first cell *A* (Fig. 2A) and the main separation in the second cell *B* into which the gas flows from the center to the periphery. Previous failures of similar apparatus was due to working on variable output, as a result of which, it often occurs that the velocity of rotary motion of the gas is too feeble to be efficient.



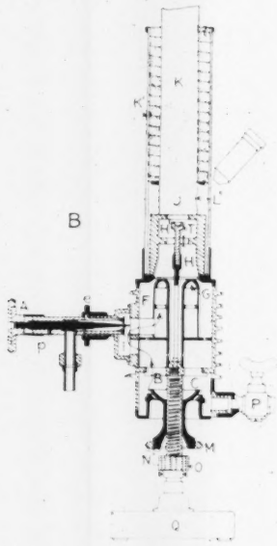


Fig. 2 A Centrifugal Tar Separator, B Comburimeter

A. Guillet in a paper on *Purification*, investigates a curious anomaly in the purification of gas by successfully passing it through three purifiers. It appears then that the gas which has not been completely purified in the second stage does not materially change its composition while passing through the third stage. This phenomenon can be explained by admitting that there is a certain ratio between the quantities of hydrocyanic acid and hydrogen sulphide in the gas at which hydrogen sulphide does not any more convert oxide of iron into a sulphur compound. Hydrocyanic acid may in fact decompose iron sulphide and set at liberty the hydrogen sulphide present. Therefore, it is quite admissible to believe that in the midst of a gaseous mass containing hydrocyanic acid, oxide of iron and hydrogen sulphide may be placed side by side without any chemical reaction between these two latter bodies taking place. This would explain why the gas containing small amounts of ammonia is purified easier than gas previously well washed. Very often hydrocyanic acid and hydrogen sulphide are absorbed together, but at a velocity which varies in accordance with external conditions. If two per cent of air be present, the hydrogen sulphide is absorbed first, in

the first stage of the purifier, and the hydrocyanic acid next, in the second stage. The author comes therefore to the conclusion that if a plant washes out the hydrocyanic acid by the wet method in a preliminary manner, the use of purifiers in three successive stages is an error, and it is more sensible to group the purifiers so as to have only two passages of approximately equal surfaces. He recommends also not to change the body of the first stage until a sulphurization is started in the second stage. The excess of oxygen in the gas after passing the first stage charged with fresh material is sufficient to regenerate the second stage, the service of which may be prolonged therefore by several years. In the discussion which followed Mallet stated that when the gas comes out unclean from the third stage, that means that the hydrogen sulphide and the hydrocyanic acid therein are in a state of equilibrium which does not permit purification at the usual velocities of from two to four mm. (0.078 to 0.157 in.) per second.

In the next paper, Grebel and Velter give an account of comburimetric tests and a description of the comburimeter designed by Velter. The comburimeter is an apparatus used for determining the quantity of air necessary for the perfect combustion of a gas. The essential parts of the comburimeter shown in Fig. B are as follows: The entrance of the gas at *A* is regulated by the needle *p* which closes more or less the orifice of the injector *i*. Another device connected with the injector permits to regulate the admission of primary air to the burner. In moving forward and back, the screw *e* carries with it the disk *d* of the injector (not shown on the drawing), and throttles at *d* more or less the entrance of the portion of the total air which, as primary air, is admitted to the burner along the path shown by the arrow. The next essential member is the air admission chamber *B*, which may be closed air-tight by the valve *C*. The movements of this valve are regulated by the indexed screw *N*, moving in front of a graduated drum *O*. As a rule, the air necessary for the working of the comburimeter is brought in by the draft of the chimney *K* across the throttled annular orifice between the valve *C* and its seat, but cock *P* located on the side permits the admission of a certain amount of measured air into the chamber *B*, even when the valve *C* is closed entirely. The next essential element is the annular burner *G*. A part of the air admitted into the chamber *B* mixes at *d* with the gas coming from the injector *i*, while the other part of the total air is distributed in the central space and in the peripheral chamber *F*. The fourth essential element of the apparatus is constituted by the combustion chamber *H* and the control chamber *H'* lined with asbestos and separated by a fire-clay diaphragm provided with a calibrated opening *I*. Both of them end in an identical diaphragm J. In the chamber H' is located the central support *C*, the purpose of which is to carry a cupelling crucible made of fire-clay for absorbing the oxide of lead during the tests; it contains a control piece of lead. A chimney of blackened copper fitted to the combustion chamber and consisting of a central tube *K*, with a spy window *L*, the bottom of which is enclosed in a crystal cylinder jacket *K'*, finishes the apparatus.

In order to determine whether the quantity of air admitted into the apparatus does or does not produce perfect combustion, it is sufficient to observe the surface of the little lead bath through the spy window *L*. In a reducing atmosphere, the bath appears darker than the cupel. It reflects mirror-like on the walls of the furnace. In slightly oxidizing atmosphere, the surface which darkens right away, is covered by tongues of colored oxides, running in all directions; when the ratio of gas to air is within close limits, that is in the neighborhood of perfect combustion, the appearance of the surface of the bath frequently passes from one state to another. As a criterion of neutrality of combustion must be taken the tendency of the litharge tongues to disappear and not to appear. From experiments made by Bertin, it appears that the sensibility of the comburimeter is perfect and the slightest variation in the proportions of the air causes the appearance or disappearance of the colored tongues on the surface of the bath. In fact, the lack of oxygen is more rapidly indicated by the disappearance of litharge coloring on the surface of the lead bath than by the carbonmonoxide reaction over the iodic acid. This apparatus permits also to determine the relative comburivority of a gas by operating with a constant opening of the air valve C. A further advantage of this apparatus is that it permits the control of manufacture of the most different gases, even such as do not produce any lighting effects, the latter not being possible with such indicators as those of Lowe and Methwen.

Bigeard presented a paper on the causes of *internal attacks on cast iron piping*. He mentioned that at Angers, small diameter cast iron pipes have been obstructed by spongy brittle deposits containing up to 40 per cent of iron, sulphur and silica. The interesting fact is that the large proportions of sulphur and silica, such as determined by analysis, in the deposits do not correspond to the small proportions of those bodies in cast iron. In the discussion the opinion was expressed that the sulphur and hydrocyanic acid, also found there, may be due to incomplete cleaning of the pipes.

The Meter Company exhibited a *device for insuring the safety of gas meters in night time*. Instead of closing the main cock, the consumer may before going to bed turn this device in such a manner as to permit the flow of only a limited quantity of gas, sufficient for any purpose of lighting during the night time, but too small to cause any accident in case of a leak. Further, a safety valve prevents the danger of excessive leaks due to forgetfulness in closing the main cock after the meter has been put into normal service and acts automatically in case of a leak in the internal piping.

Masse explains very clearly the principle of establishing *a rule of calculation of gas conduits*. As a rule, use is made of the Aubuisson formula

$$h = K\frac{Q^2 L}{D^5}$$

where h denotes loss of head in mm. of water, Q output in cu. m. per hour, L, length of conduit in meters, D, its diameter in centimeters, k a coefficient which varies with various investigators (Monnier makes k = 0.84). After numerous experiments on cast iron conduits, Aubéry has adopted the following formula:

$$h = 1.625\frac{Q^{1.85}\,L}{D^{4.92}}$$

corresponding to a density of gas equal to 0.44. This rule permits in general the solution of problems relating to the transportation of gas through a conduit of any length. In the discussion which followed, Grebel called attention to the fact that the formula of Aubéry is close to that of Monnier

and Blaess where the output is a function to $p_1 - p_2$ (p_1 exit pressure, p_2 entrance pressure) and not the more modern formulæ of Unwin and the Chicago Gas Companies where the output is a function of $p_1^2 - p_2^2$. On the other hand, however, this formula could be made to show an agreement with the results of the experiments made by the French Suburban Gas Company with the formulæ where the loss of head $p_1 - p_2$ is a function of the output Q raised to the 0.85 power while in all the formulæ, ancient and modern, the second power is adhered to in accordance with the theory of flow of fluids in pipes.

Hydraulics

Hydroelectric Installation in Kabylia (*Installation hydro-électrique en Kabylie*, L. Neu. *Mémoires de la Société des Ingénieurs Civils de France*, ser. 7, vol. 67, no. 5, p. 597, May 1914. 11 pp., 8 figs. *d*). The article describes a hydroelectric installation in Kabylia, Africa. The installation uses a double type Francis water wheel provided with a Minetti speed regulator with a servo-motor operated by oil under pressure. Fig. 3A and B show the construction of this regulator. Its essential parts are the piston K moving in a cylinder C, the two high pressure rotary pumps P_1 and P_2, distributing double seat valve V and fly-ball governor T. Each of the ends of the cylinder communicates on one hand with the delivery piping of one of the pumps and on the other hand with a discharge passage A_1 or A_2 opening into the reservoir R. When the engine runs at a normal speed, the valve V which controls the openings A_1 and A_2 is in its middle position and therefore leaves open equal amounts of cross section of the two passages, so that the oil carried into the cylinder can return back to the reservoir without exerting any pressure on the piston. But as soon as the speed of the engine begins to decrease or increase as compared with normal speed, the valve V, in consequence of a variation of the work of resistance, is shifted under the influence of the centrifugal governor and comes to cover up one of the discharge passages. Then the oil delivered by the pump on the closed side, not being able to return to the reservoir, forces the piston to move in a corresponding direction, this motion being transmitted later on to the gates of the turbine by means of the lever H connected with the governor shaft W.

The rotary pumps can deliver a working pressure up to 10 atmospheres. The distributing valve is perfectly balanced; the levers a, b, and c provide for its return to its middle position, and a very small displacement of the distributing valve is sufficient to start immediately the servo-motor. All changes in speed resulting from a retardation of its functioning are suppressed owing to the incompressibility of the oil which is used to insure the instantaneous action of the speed regulation. The hydraulic pressure acting on the servo-motor does not act all the time, but goes into action only at the very instant when the speed regulation has to take place, its value being proportional to the resistance offered by the governing organs of the turbine water supply system. If it is desired to stop the action of the governor while in operation without at the same time stopping the pumps, the valve is lifted and both ends of the cylinder C placed into communication with one another. This valve also acts as a safety valve by limiting the maximum pressure in the apparatus to that necessary for operating the gates on the turbine plant, and comes into action in case of accidental ruptures which may occur when a hard body gets into the turbine regulation device. The time required for closing is about three seconds, the regulation of the turbine being practically instantaneous.

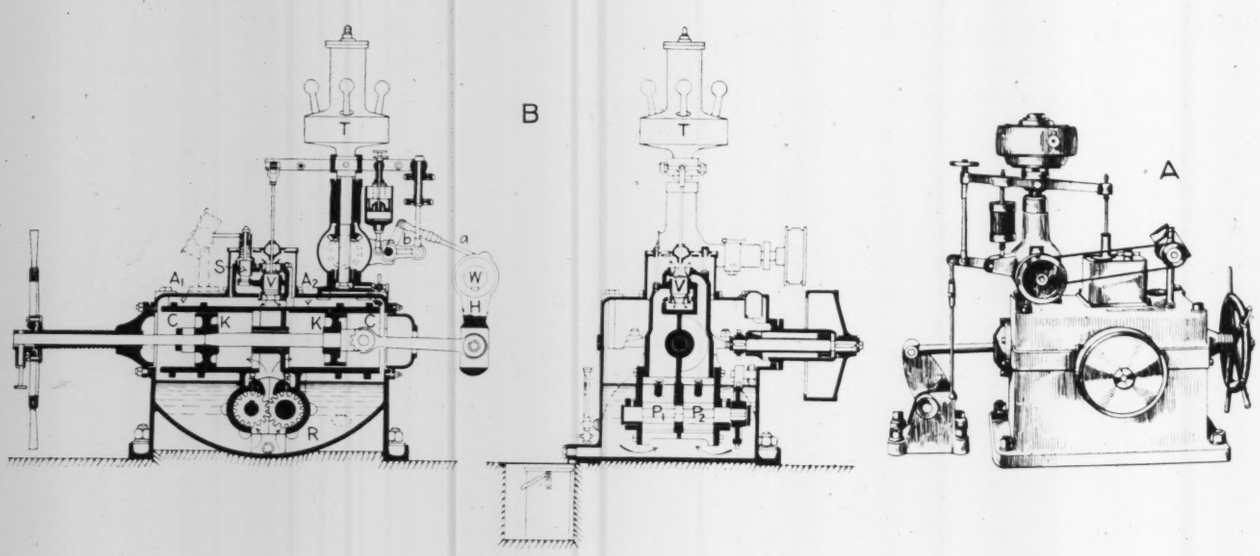


Fig. 3 Minetti Hydraulic Turbine Speed Regulator

Internal-Combustion Engineering

Modern Cooling Devices for Use on Internal Combustion Engines (*Neuere Kühleinrichtungen für Verbrennungsmotoren*, Dr. F. Georgius. *Dinglers polytechnisches Journal*, vol. 329, no. 29, p. 453, July 18, 1914. 3 pp, 8 figs. *d*). The article describes modern devices for cooling internal combustion engines. While the cooling forms a very important part in the operation of internal combustion engines, one of the most dangerous occurrences as far as the life of the cylinders is concerned is the rapid variation in temperature and stresses produced thereby, due to the sudden flow of cooling water after it has been interrupted for

a time through some cause. For a long time, water was the main cooling agent, but lately the Augsburg-Nurenburg Machine Company has turned to the use of oil with which very good results have been obtained in the engines supplied to the Dutch warships. The oil in this case runs in a closed circuit and is cooled by a flow of water. It is pumped under a pressure of from 2.5 to 5 atmospheres, and is used both for cooling and in some instances for lubricating, as for example in main bearings, driving-rod and crank shaft. The present article describes the cooling devices placed on the market by Krupp, the German General Electric Company, Goudard & Mennesson, Längerer & Reich, Daimler Motor Company, Kreul & Hesselman. An interesting solution of the problem of cooling is presented by Kreul. He avoids the use of a special water service pump by using a pump placed on the cylinder cover; in this pump the extension of the piston rod works as a piston as shown in Fig. 4A. The pump *a* is placed over the cylinder cover *f* and the piston rod *b* acts as the piston of this pump. The liquid handled by the pump is conducted by the pressure pipe *d* on to the cylinder *e* and the cylinder covers *f* and *g*. The water circulation takes place through the piston rod *b* which is for this purpose provided with a non-return valve *k*; during the suction stroke this valve opens; during the pressure stroke the water is compressed partly through the piping *d* and partly by means of the piston rod *b*. As a result no separate drive for the cooling water circulation pump is required. This arrangement, however, can be used only in the case of engines which have space available for the pump over the cylinder cover.

For engines in which the fuel injection nozzles are located on the cylinder cover, it is advisable to have a special system of cooling the nozzle passage in the cover. To do this, Hesselman (Figs. B and C) provides for a special water chamber around the fuel passage in the cover separate from the general water chamber. The opening in the cover is divided by the wall *a* into two spaces *b* and *c*, connected with one another by the passage *d*. The outer chamber is connected by the opening *e* with the water jacket of the cylinder while the water runs away through the passage *f*. Radial grooves *g* are used in order to prevent the water coming in through *d* from flowing through the inner space *b* in a peripheral direction and to force the water to run along the walls of the nozzle passages.

When the cooling liquid is not brought in through the

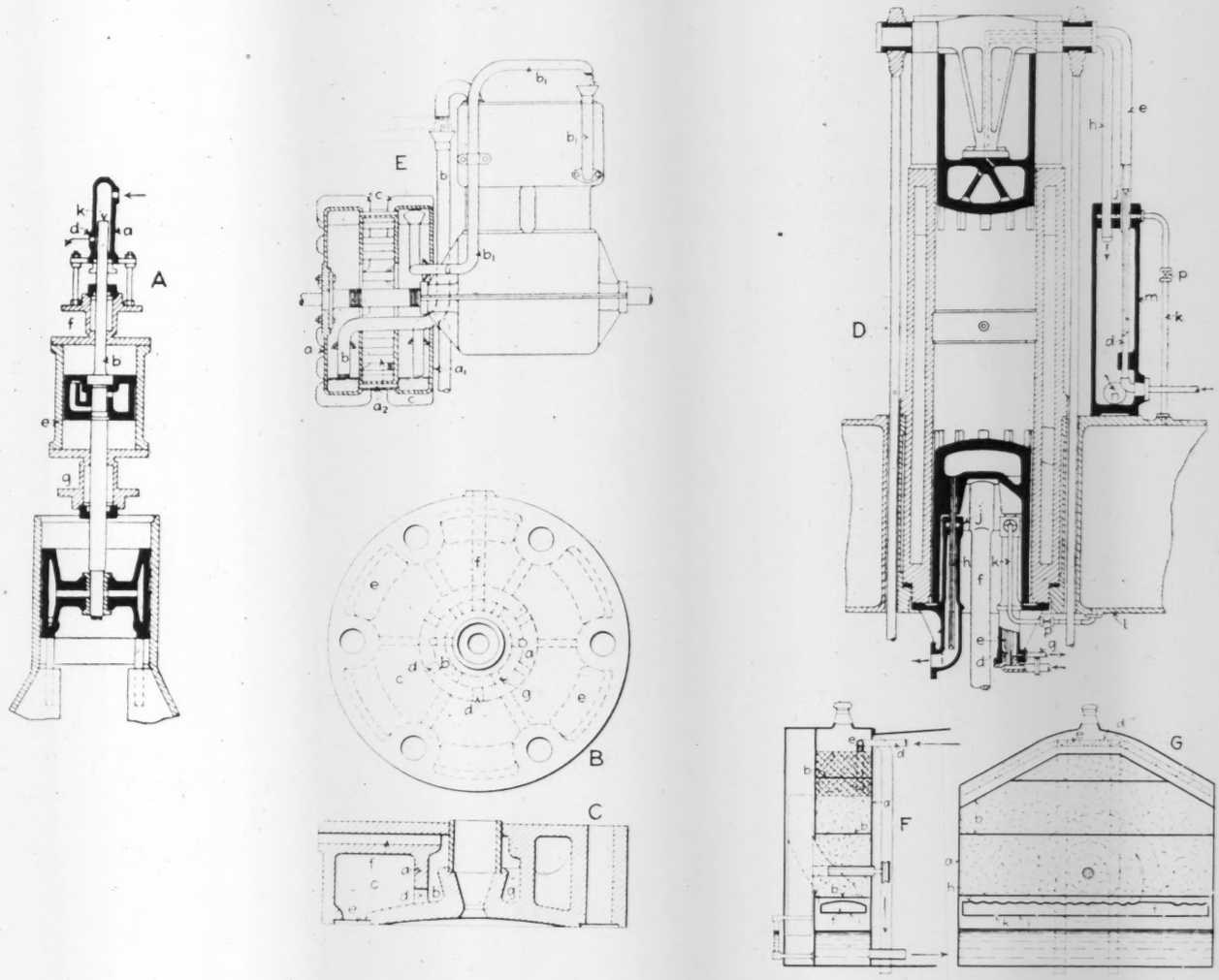


Fig. 4 Cooling Devices for Use on Internal Combustion Engines

piston rods, special pipes attached to the piston and dipping into a fixed tank are used. In order to provide for a good packing of these pipes in the tank walls, the German General Electric Company uses the gaseous pressure medium flowing in a direction opposite to that of the cooling medium. For example, if an internal combustion engine with opposed pistons such as is shown in Fig. D is used, than the cooling medium (in this case, water) is brought on to the lower piston by a pipe *d* and another pipe *e* fixed to the piston and having a slight play between it and *d*. The liquid which leaks between the pipes *d* and *e* is caught in the tank *f* through the upper wall of which the pipe *e*, provided with mechanical packing, passes through. The leakage is then conducted away by the pipe *g*. The cooling water, at a higher temperature, after it has done its work, is taken away from the piston through pipe *h* and tank *i*. The upper ends of the tanks *f* and *i*, permitting a passage of the pipes *e* and *h*, are provided with chambers *j* which are connected with the scavenging air tank *l* by the pipe *k*. The air compressed to a pressure above atmospheric, reaches from the tank *l* into the chamber *j* and from there through the pipe packing in part directly into the atmosphere but mainly into the tanks *f* and *i*; while passing into this latter it forces the liquid back into them and thus prevents the lubricating oil from getting into the driving parts as well as mixing with the cooling water. The air itself is later on allowed to escape together with the leakage of the liquid. In the case of the cooling arrangement of the upper piston which in all other respects is designed in a similar manner to that of the lower piston, the admission pipe *d* and return flow pipe *h* open into the same tank *m*, the connection between the pressure chamber *j* and scavenging tank *l* occuring through the pipe *k*. As a means of packing, may be used a part of the air compressed either in the working cylinder or in the pumps. The pressure of the air used as a packing medium may be regulated by the valve *p* and since the cooling water is certain not to mix with the lubricating oil, it may be immediately used again after it has been cooled to its initial temperature. Another arrangement used by the same concern in order to prevent a leakage of the cooling medium through a movable pipe connection consists in driving the cooling medium through the piston and pipe connections not under pressure but under suction. In all of these cooling chambers and pipes the pressure is below atmospheric, the flow of the liquid being prevented thereby. For this purpose any pump may be used, and the pressure piping can open into the suction chamber.

Among other types may be used also cooling arrangements consisting of a rotating tank and stationary pipe system. By the rotation of the tank, owing to centrifugal force acting on the liquid, a pressure and suction are produced at the openings of the admission and exit pipes respectively. A cooler designed on this principle by Goudard and Mennesson is shown in Fig. E. In this case two drums *a* and a_1 located side by side on the same axis and interconnected by a bundle of pipes a_2 are used as cooling chambers. A stationary system of piping is connected with this rotating drum by the central opening in such a manner that the liquid is admitted into one of the drums and flows out again through the other. The pipe ends *b* and b_1 have a free opening into the respective drums without there being any need for packing. The rotation of the drums driven with a considerable velocity by the engine produces without any further appliances a circulation of the cooling medium through the joints of the engine. In order to prevent a syphonic action which might take place while the engine is stationary, the system of piping is interrupted both at the admission and exit ends on the cooling jacket. The cooling drums are sometimes made of aluminum. Owing to the fact that the two drums are connected with one another by the system of piping a_2, freely surrounded by outside air, a good cooling of the cooling water of circulation is produced. If necessary, fins *c* may be added to intensify the cooling action.

The arrangement permitting a rapid cooling of the circulating water after coming from the water jacket has the further advantage that the supply of cooling water may be maintained as low as possible. This circumstance is of particular importance in the case of engines used on vehicles of various kinds. In order to achieve this, Längerer and Reich make the circulating water to come into direct contact with air (Fig. F and G). A chamber *a* is divided into two by a sieve *b*. The space is filled with a filter mass. The water coming from the engine jacket arrives through the pipe *d* and thus reaches the atomization pipe *e* which distributes it over the entire cross-section of the cooler. In the lower chamber of the cooler an air atomizer *f* is built-in, the upper surface of which is arched laterally and has a wave-shaped appearance in the longitudinal direction, there being provided at the crests of the waves slots *h*, while in the lower flat surface *i* there are a number of openings *k*. The water entering through the pipe *e* flows through the sieve and the filtering mass, and later on goes again to the engine jacket from the lower collecting tank. The air to the atomizer *f* is supplied by a fan driven by the engine or some similar appliance. It enters into the cooler uniformly distributed through the longitudinal slots *h* and flows counter current to the water coming from the engine jacket, this ensuring an intimate contact between the cooling air and the water. The sieves serve to prevent the filter mass from packing too tight. The well known system of cooling used on the motor cars of the Daimler Company is also described in the article.

Steel Cylinders (*Stahlzylinder*, F. Klinkenberg. *Der Motorwagen*, vol. 17, no. 19, p. 451, July 10, 1914. 3 pp., 1 fig. *d*). While the manufacture of cast iron cylinders for motor traction has reached a high stage of perfection involving the use of specially adapted high grade cast iron, determined efforts are made in Germany to promote the use of steel cylinders, especially where the lower weight of the latter is a factor of importance. In Germany, a concern called the Steel Motor Company Ernst Jaenisch & Co., in Berlin, has of late been making a specialty of the manufacture of steel cylinders for automobile engines. The manufacture has been carried on in a well regulated manner of mass production, with specially designed machine tools and production to close dimensions. The en-bloc type is mainly produced. Fig. 5 shows a four cylinder engine cast en-bloc 80 mm. (3.14 in.) bore and 130 mm. (5.118 in.) stroke for a motor rated at 10 h.p. under the German motor tax rules. The general arrangement of the valves and suction and exhaust connections does not differ from normal construction, but one can see the extreme care taken in the execution of the passages, valve chambers and cooling water jackets.

The walls, contrary to what is done in the case of cast iron cylinders, are made extremely thin and in some places, for example the cover and cooling water jackets, are approximately not more than thin sheet steel; even the valve chamber plugs are nothing but light steel pieces. The suction passages are, in accordance with the modern practice, placed inside the cylinder block while exhaust piping is located on the outside and held by means of thin flanges. The purpose of locating the exhaust piping on the outside is to give a chance for better cooling since when, experimentally, the piping was placed inside the cylinder block, it resulted in an irregular and one-sided heating of the block and extreme stresses in the material. The bend in the exhaust pipe is also very light and consists of thin steel piping 0.059 to 0.078 in. thick.

The cylinders are made of an excellent special grade of steel and machined throughout. They are adapted to any compression pressure which may arise and can withstand for a long time all possible stresses, which is not the case with the ordinary steel cylinder with the *head* simply welded in. The valve guide bushings are made of a special steel casting and either set in or pressed in in the corresponding steel sleeves of the block body without requiring any further means of fastening. A special process not described in the article is used for joining the cylinder with the water jackets and the latter with the cover (from other information it would appear, autogenous welding is used for this purpose). The machining of the inside of the cylinder is done in a very simple manner, the cylinder being bored and then simply reamed with a reamer of suitable dimensions.

There might be some trouble from the difference between the cast iron piston rings and the steel cylinder; it is, however, known that the surface of the cast iron cylinder hardens within a short time so that the conditions of working in the steel and cast iron cylinders are about the same and no trouble worth speaking of has been observed hitherto in the operation of steel cylinders in this respect. With respect to cooling water circulation, it is essential that the cooling water after its entrance into the cylinder block be admitted directly and automatically under the hot exhaust valve chamber before it is allowed to rise further; for this purpose, special passages are provided which can be seen on the figure of the block looking from above under the cross-section of the suction pipe. The design shown in the drawing involves cooling by means of a pump, but there is also a special construction with automatic cooling by the thermo-syphon system.

Three main advantages are claimed for the steel cylinder of this type of construction: In the first place, low weight, approximately one third of that of the cylinder of equal output in cast iron, which is of importance for automobile construction; in the second place, the uniformity in the distribution of material and possibility of using thin walls for the cylinder water jacket, exhaust piping and so on, permit very advantageous effects in the introduction and dispersal of heat. The thermal efficiency of an engine and its output, especially when operated at a constant forced load, depend to a very high degree on the transmission of heat to the cooling water and the dispersal of heat to the atmosphere, and the advantages presented in this respect by the use of steel permit higher compression pressures than would be the case in similar cast iron cylinders. The third important advantage is the possibility of using the exact shapes and dimensions inside the cylinder block which are required by the designer of the engine, without having to count with the eventualities of casting as is the case in cast iron cylinders. The use of steel permits the employ of any means of construction and any variation of cross-section of passages. The main disadvantage of this type of construction is its higher price; this, however, depends materially on the extent and method of manufacture and may not count so much in view of the important advantages lying on the other side.

Pumps

Concerning the Calculation of Water-Jet Air Pumps (*Zur Berechnung der Wasserstrahl-Luftpumpen*, Professor C. Pfleiderer, *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 24, p. 965, June 13, 1914, and no. 25, p. 1011, June 20, 1914, 12 pp., 16 figs. *text*). The article presents methods of calculation of so-called water-jet pumps; that is, de-

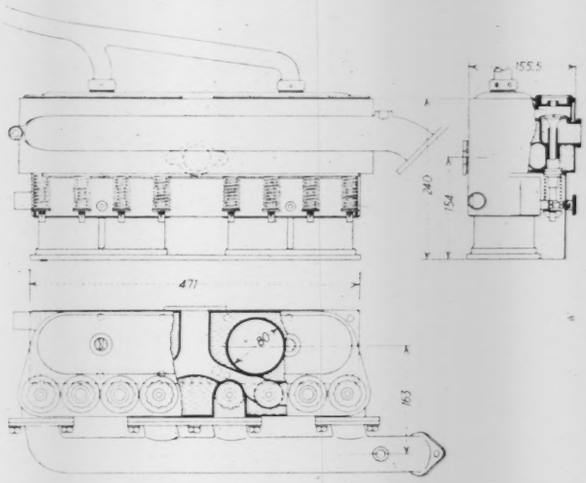


Fig. 5 Steel Cylinder for Gasoline Engine

vices in which the kinetic energy of the water jet is used to deliver gases, such as air, from a level of low pressure to a level of high pressure. The author derives a fundamental equation of the water jet pump, and shows that the nozzles of these pumps, when low suction pressures are used, must have contracting-expanding cross sections such as are used in the Laval nozzle. He shows further the conditions which lead to an oscillation in the air vacuum and cause interruptions in the operation of the pump. He develops a process which gives means to prevent the interruptions in the flow of water and undesirable variations in its velocity. He determines further the efficiencies of water jet pumps and proves that such a pump works the more efficiently, the higher the *velocity* of the water and the smaller the *amounts* of water, on condition, however, that the amount of water is still sufficiently large to handle the respective amount of air to be delivered. He gives several examples showing processes used in the calculation of jet pumps and distinguishes between nozzles with a straight central line and annular nozzles and shows that in the case of the latter the circular motion of the water requires the use of special equations. He proves further that water jet pumps actually behave like piston pumps with an infinitely small clearance, in so far as they have a tendency to maintain the amount of

air taken in constant, notwithstanding the variations in the suction pressure.

THE SPIRAL CHAIN PUMP (*Die Spiraldrahtpumpe, Kraft und Betrieb*, vol. 3, no. 6, p. 89, June 27, 1914, 1 p., 2 figs. *de*). In *The Journal* August 1912, pages 1252 and 1253, was described and illustrated a new device for raising liquids consisting of a closely wound spiral with the chain inside designed by the French engineer Bessonet-Favre. At that time, no precise data of tests was available. The chain pump of this design presents certain advantages in being able to handle equally well cold or warm, clean or dirty water, and because it has no valves, stuffing-boxes or packing, it must be very simple in operation and cheap to install. The following data of tests may be of interest. To convert the data to American units, it is necessary to multiply the volume of water given in cubic meters by 35.314 which will give cu. ft. and the h.p. by $\frac{75}{76}$ which is the conversion constant to change from continental horse power to the corresponding American unit.

TABLE 1 DATA AND TESTS OF A BESSONET-FAVRE CHAIN PUMP

Diameter of Chain, mm.	Number of Wire	Output and Power Consumption for a Delivery Head of						
		10 m.	20 m.	30 m.	40 m.	50 m.	60 m.	
24	1	3900	3650	3350	....	....	....	cbm. per hr.
		0.25	0.4	0.5	....	....	....	h.p.
27	1	4500	4350	4150	3900	3600	3250	cbm. per hr.
		0.3	0.45	0.6	0.7	0.8	1.0	h.p.
32	1	5500	5300	5100	4900	4700	4500	cbm. per hr.
		0.35	0.55	0.7	0.8	1.0	1.2	h.p.
40	2	10000	9800	9575	9325	9050	8750	cbm. per hr.
		0.6	1.0	1.2	1.8	1.7	2.1	h.p.
55	2	15000	14600	14200	13800	13400	13000	cbm. per hr.
		0.9	1.5	1.7	2.2	2.6	3.0	h.p.
62	3	20000	19500	19000	18500	18000	17500	cbm. per hr.
		1.1	2.0	2.3	2.9	3.5	4.1	h.p.
80	3	30000	29500	29000	28500	28000	27500	cbm. per hr.
		1.75	2.9	3.5	4.5	5.4	6.3	h.p.

Steam Engineering

FRICTION (TESLA) TURBINES (*Les turbines à frottement ou Tesla*, Professor E. Mérigeault. *Revue de Méchaniques*, vol. 34, no. 6, p. 538, June 30, 1914. 7 pp., 6 figs. *t*). The article gives an attempt at construction of the theory of the Tesla turbine as well as a discussion of its theoretical efficiency. As regards the possible improvement of this type of turbine, the author states that it lies in the direction of decreasing as far as possible all internal friction which causes loss of efficiency, and recommends the following methods. First, to use disks, the internal and external radii of which are close to one another so that a molecule of water may escape after having made a single turn. At any instant, therefore, there will be present only one spiral of current and this spiral will approach in its shape an arc of a circle. Second, to add to the disks, spiral transverse partitions directing the current which are so close to one another that they will be like a streamline passing in a channel between two successive partitions. In this way the current of fluid will exert on the entire periphery a friction against metallic walls combined with a movable wheel. Here again each spiral will come very close to an arc of a circle.

EVAPORATION TEST OF A STEAM BOILER EQUIPPED WITH IMPROVED WEFER GAS FIRING (*Verdampfungsversuch an einem mit der verbesserten Wefer-Gasfeuerung ausgerüsteten Dampfkessel*, A. Bütow and O. Dobbelstein, *Glückauf*, vol. 50, no. 26, p. 1030, June 27, 1914, 2 pp., 1 fig. *de*). This article is practically a continuation of the article on the same subject and by the same author, abstracted in *The Journal*, July 1912, page 1118, where previous tests of the same system of firing on a double boiler have been reported. Since then the Wefer system of firing has been improved and reconstructed in the form shown in Fig. 6. The coke-oven gas passes from the gas chamber *a* through 40 pipes *b* into boiler openings *c* of the graphite body *d* where it mixes with the air entering through the annular sliding valve *e* and burns up in the fire room *f*. The entire burner is set in a cylindrical extension *g* of the firebox frame. The firebox is directly connected with the external atmosphere by a centrally located pipe 200 mm. (7.87 in.) inside diameter; in the former design this pipe was closed by the loosely lying explosion cover, which now lies over the gas chamber; the new arrangement has the advantage of providing a larger free cross-section for possible explosion shocks. In the older design, there were only 25 gas admission pipes which formed a closed central bundle; the present arrangement makes possible a better subdivision of the gas, and mixing between the gas and air. The burner openings have been shifted to the end of the fire tube by

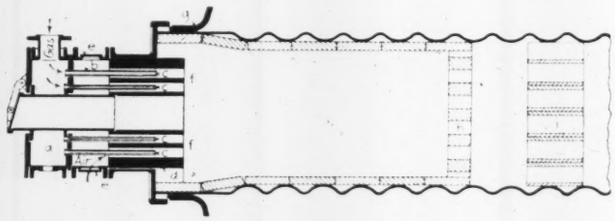


FIG. 6 IMPROVED WEFER GAS FIRING

building the burner into the extension *g* and by this means the fire tube has been made available for useful heating throughout its entire length. Finally, in order to provide as large a contact space as possible between the gas mixture and the incandescent pieces of fire clay and to achieve thereby a complete combustion, a layer of pipe-pieces *i* has been placed behind the fire brick grating *h*. The arrangement of the plant as compared with that reported previously has been changed somewhat through the installation of a gas holder of 40,000 cbm. (1,412,580 cu. ft.) capacity which permits to maintain the gas pressure quite steady, contrary to what was the case in the former tests. The benzol plant has been enlarged so that the gas is now practically free from benzol and therefore of a somewhat lower heating value. The tests were made on April 26, 1914, with a double flue boiler of 115.4 qm. (1135 sq. ft) heating surface. Its results are shown in table 2. A comparison of these data with the data obtained in the previous tests shows that notwithstanding the increase in the boiler output from 21.83 to 28.38 kg. per hr., the total efficiency of the plant went up to 84.6 per cent or increased by 5.4 per cent. It must, however, be borne in mind that in the former tests the heating value of the gas, as obtained by analysis, has not been referred to the temperature of deter-

mination. If this fact be taken into consideration and the difference in heating value of 105 W E (189 B.t.u. per lb.) be introduced into the calculation, the rise in boiler efficiency will be reduced to 3.4 per cent, which still shows that the change in construction has improved the Wefer boiler.

TABLE 2 DATA OF TESTS OF AN IMPROVED WEFER GAS FIRING INSTALLATION

Duration of test		8 hr.
Steam pressure		12.0 atmospheres gage
Feedwater consumption, kg lb.		26608.58537
Steam generation:		
from water at 0 deg. cent. (32 deg. fahr.) to steam at 100 deg. cent. (212 deg. fahr.) and 637 WE (1146 B.t.u.) kg lb.		26204.57648
Steam generation per hr., kg lb.		3275.5 7206
Steam temperature at superheater, deg. cent. fahr.		297.0 566.6
Total ~~gas, volume,~~ cbm cu. ft.		5633 198,924
Gas volume per hr., cbm cu. ft.		704.1 24864
Pressure, gage, in the gas piping, mm. water		148.0
Gas temperature, deg. cent. fahr.		35.0 95
Barometer, mm. mercury		755.3
Composition of gas, per cent:		
CO_2	1.6	
O_2	1.8	
CO	4.6	
H	52.2	
CH_4	28.8	
Heavy hydrocarbons	1.6	
N	9.4	
Average composition of flue gases, per cent:		
CO_2	8.3	
O_2	3.24	
CO		
Excess of air	1.6 times	
Temperature in the fire chamber, deg. cent. fahr.		1425 2597
Average temperature of flue gases in the flue, deg. cent. fahr.		225 437
Results:		
Output of steam at 637 WE (1146 B.t.u.) per 1 cbm of gas kg lb. per cu. ft. of gas.	4.65 0.288	
Output per 1 qm of heating surface, per hr. kg lb. per sq. ft.		28.38 2.6
Saturated steam, per cent	77.6	
Superheated steam, per cent	7.0	
Loss through conduction and radiation, per cent	15.4	
Total, per cent	100	

STEAM EJECTO-CONDENSERS (*Les éjecto-condenseurs à vapeur*, Professor Aime Witz, *La Technique moderne*, vol. 9, no. 1, p. 1, July 1, 1914, 8 pp., 14 fig. *dce*). The article describes various types of steam ejecto-condensers mainly for use with steam turbines such as the Leblanc, Parsons, Körting and Delaporte apparatus. The main interest of the article lies in the information given of tests of the latter type made by the author at the plant of the Breguet Company. The apparatus itself known under the name of ejectair has been previously described in The Journal, July 1913, p. 1183. The article describes the experimental installation used for these tests. In the first series of tests were determined the characteristic curves of the operation of the ejectair under different temperatures of the water at exit from the main condenser and at admission into the small auxiliary condenser placed between the two ejectors. The name of characteristic curve was given to the curve plotted with the fall of vacuum in centimeters of mercury as ordinates, and the admission of supplementary air in kilograms per hour as abscissæ. These curves should be plotted within the regions of approximately half load and full load, with and without cooling; the fall of vacuum would be expressed with regard to the theoretical vacuum as determined by the difference between the normal barometric pressure of 760 mm. and the vapor tension corresponding to the temperature of water in the condenser in millimeters of mercury. The comparison between the characteristics at half load and at full load should have brought out the well known theorem that the fall of vacuum referred to

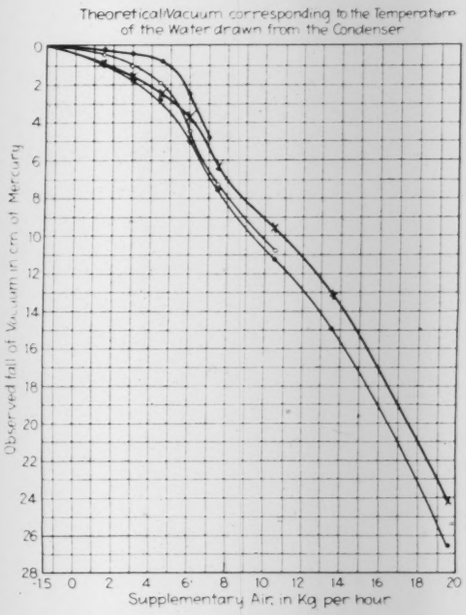


FIG. 7 CHARACTERISTIC CURVES OF THE DELAPORTE EJECTAIR

the theoretical vacuum corresponding to a given temperature of water flowing out from the condenser, depends only on the amount of air admission and not on the quantity of steam admitted to the condenser. This theorem assumes that the condenser is perfect. Its more or less approximate verification ought to give a basis for estimating the degree of perfection of the apparatus and its practical value. On the other hand, it gives a criterion of the precision of the results observed. The comparison between the curves obtained with and without cooling from atop brought out another fact, namely, that in carrying the curves down to the origin of the co-ordinates by means of an extrapolation, which, however, should not be excessive, a point is found where the action of the cooler is zero. At this point there is no more air in the condenser, and the abscissa of this point gives consequently the weight of air brought by the water of injection. At this point also, the theoretical vacuum is obtained, and its position gives a new point of control for the observations made. With the characteristics having been plotted and verified in this manner, the values for the total air admission can be deduced in grams per sec-

ond and per horsepower, and the percentage of the vacuum actually obtained can be determined as a function of the theoretical vacuum for various temperatures of water in the condenser. These new results give very interesting graphical curves obtained by using as ordinates the weight of air extricated per second per h.p.-hr., and as abscissæ the vacuums in per cent of the theoretical vacuum; thus, by taking into consideration the possible utilization of the calories expended in the apparatus on feeding it with live steam, new curves were obtained of great value. The author gives in considerable detail the results obtained in his experiment both in tabular form and in curves. On account of lack of space, we shall reproduce here only the most important curves. In figure 7, curves 1, 2 and 3 are characteristic curves. One notices that curve 4 of the vacuum taken with water coming from the condenser at about 41 deg. cent. (105.8 deg. fahr.) and for the purpose of cooling water

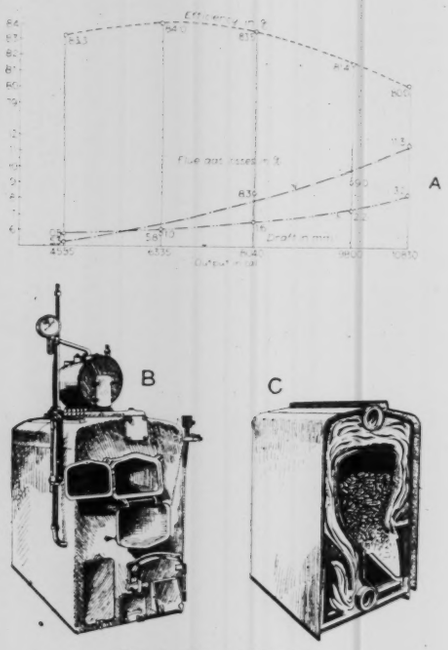


Fig. 8 Lollar Boiler

being used at about 18.5 deg. cent. (65.3 deg. fahr.) remains for a long time above curve 3 which corresponds to the same temperature of cooling water and a temperature of 40.5 deg. cent. (104.9 deg. fahr.) in the main condenser. For an admission of air of 4.5 kg. (9.9 lb. per hr.), the variation is about 18.5 mm. The two curves intersect at the origin at a point which corresponds strictly to the theoretical vacuum for the temperature of the water taken from the condenser which is an important proof of the precision of the results obtained. This point of intersection has for abscissa the value of — 1.5. The author comes to the conclusion that this expresses the admission of supplementary air due to the water of injection in the condenser and perhaps also due to leakage of some other sort. In order, therefore, to find the total air admission, the values of the abscissæ will have to be increased by 1.5 kg. or 3.3 lb. The author also confirms the previously known fact that the admission of the air in the upper part of the injector produces a less depressing effect than when the air is admitted directly into the condenser.

Lollar Boilers and Radiators (*Lollar-Kessel und Radiatoren*, Pradel. *Zeits. für Beleuchtungswesen, Heizungs-Lüftungs-Technik*, vol. 20, no. 17. *de*). The author describes the so-called Lollar boilers and radiators, a type of sectional boilers used to a considerable extent in Germany. While coke is the natural fuel for this type of boilers, boilers have been also built for use with brown coal and lignite briquettes. Fig. 8A shows the efficiency loss through flue gases and draft in the case of five different loads on the boiler. Figs. B and C show the construction of such a boiler designed to use lignite briquettes and generate low pressure steam. Fig. B shows the boiler in actual construction and Fig. C with the front section removed. The main advantage of the Lollar briquette boiler consists in the fact that the firing is done on the half gasification principle, the gasification of the fuel taking place on an inclined grate which through constant shaking is automatically kept free from clogging with ashes. The auxiliary air is preheated to a very high degree before it reaches the combustion chamber and on this account causes the complete combustion of the gases in the combustion lying above the grate. This combustion chamber is separated from the boiler by plates of refractory material. The admission of the main and auxiliary air of combustion occurs through a common fresh air valve operated either by hand or by a separate governor. This arrangement has the advantage that the ratio of the two kinds of air admitted remains identical at all times and for all loads, and in this way a perfect combustion without soot formation is secured under all circumstances independently of the performance of the attendance. It has been many times found that the gases developed during the combustion of lignite briquettes are apt to cause explosions when fresh air is suddenly admitted, thus endangering the boiler attendants. In order to prevent the occurrence of such explosions, the Lollar boiler is provided, as shown in Fig. B, with the screen door over which is placed the charging door proper. This latter is connected with the air valve in such a manner that when it is opened, the air valve closes; as a result the air enters in a state of fine sub-division through the yet closed screen door and such gases as may have been present in the charging chamber have time to be quietly consumed before the screen door is opened for charging the fuel.

Miscellanea

Comparative Tests of Mineral Lubricating Oils with an Addition of 1.5 per cent of Oildag (*Vergleichende Untersuchungen von Mineral-Schmierölen mit 1.5 vH Zusatz von Oildag*, A. Saytzeff, *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 29, p. 1174, 3½ pp., 8 figs. *ce*). The article gives a brief account of tests carried out in the Laboratory of Applied Mechanics of the St. Petersburg Polytechnic Institute in the Summer of 1913 on the use in lubrication of pure oil and oil with an addtiion of 1.5 per cent of Oildag. The oils used were the Gargoile Dynamo Oil E. and Etna Engine Oil of the Vacuum Oil Company. The tests were made in accordance with the Petroff process for the determination of the coefficient of internal friction η, and, by means of the Martens oil testing machine, for the determination of the frictional resistance W and the coefficient of friction f. The article gives the data obtained in the form of tables and curves. It was found that, as compared with pure dynamo oils, oil with an addition of

1.5 per cent Oildag at temperatures above 30 deg. cent. (86 deg. fahr.) differed but slightly from one another with respect to internal friction; it was advisable to add a little Oildag to thin oil, mainly when the bearings begin to heat; the mechanical friction of thick oils was reduced by about 7 per cent by the addition of 1.5 per cent of Oildag. In every case, the addition of one to two per cent of Oildag resulted in material reduction of the consumption of lubricating oil.

ENGINEERING SOCIETIES

ASSOCIATION OF AMERICAN STEEL MANUFACTURERS

As the publications of the Association were not available at the time of making the abstract, the present information has been taken from the *Industrial World*, vol. 48, no. 29, July 20, 1914, p. 857. The Association of American Steel Manufacturers has printed specifications as revised April 21, as follows:

Structural and boiler steel.
Concrete reinforcement bars rolled from billets.
Rail steel concrete reinforcement bars.

In structural and boiler steel, the principal changes are the narrowing of the tensile range for fire box steel from 10,000 lb. to 8,000 lb., and new tables covering the permissible variations in gage and weight of sheared plates. These tables replace tables which were adopted by the association in 1896 and which have since been widely copied into nearly all plate specifications. The present tables, giving percentages of permissible variation up and down respectively, according to different thickness and widths of plates, refer to individual plates rather than to averages. The subdivision as regards width particularly is carried out in much more detail than in the old tables.

In the specifications for concrete reinforcement, bars rolled from billets an intermediate grade of bars has been introduced, with a tensile strength of 70,000 to 85,000 lb.

In the rail steel reinforcement specification, paragraph 5 (a) reads as follows respecting tests:

One tensile and one bending test shall be made from each lot of 10 tons or less of each size of bar rolled from rails varying not more than 10 lb. per yd. in nominal weight. Should a test specimen develop flaws or should the tensile test specimen break outside the middle third of its gaged length, it may be discarded and another test specimen substituted therefor. In case a tensile specimen does not meet the specifications, an additional test may be made.

ENGINEERING ASSOCIATION OF THE SOUTH

Proceedings, vol. 25, no. 2, April, May and June 1914, Nashville

Control of Mississippi Floods, Professor W. H. Schuerman
Report of Special Committee on Nashville Smoke Ordinance, C. H. Simpson (abstracted)

Report of Special Committee on Nashville Smoke Ordinance, C. H. Simpson (24 pp., *g*). The article presents some data on the history of the Nashville smoke ordinance as well as the text of that ordinance. One of the features is that it permits dense smoke for thirty min. of the first hour in which the boiler is being fired up and twelve min. in each hour following should it be necessary to clean out or start a new fire. At the present time, Nashville has a thoroughly organized Smoke Department. Any person who violates any of the provisions of the smoke ordinance except as otherwise provided therein shall be find not less than $5.00 and not more than $25.00 for each offense.

FRANKLIN INSTITUTE

Journal, vol. 178, no. 2, August 1914, Philadelphia

Modern Research in the Metallurgy of Iron, Allerton S. Cushman
Producer Gas From Low Grade Fuels, R. H. Fernald (abstracted)
Locomotive Superheaters and Their Performance (discussion, abstract of the original article in The Journal, August 1914, p. 168)

Producer Gas From Low Grade Fuels, R. H. Fernald (20 pp., 20 figs. *de*). The article discusses the production of producer gas from low grade fuel mainly with the view of indicating the commercial conditions influencing the installation of low grade fuel producer plants. As compared with the steam plant, the producer gas installation is about twice as economical. A comparison is made between one of the most efficient steam plants in this country, the Interborough Rapid Transit Company's 59th Street Power Station in New York City, and the theoretical gas plant devised on the same scale by Mr. Stott, Superintendent of Motive Power of the same company. In the steam plant out of 970 B.t.u. put into the furnace 100 B.t.u. are realized at the bus-bars. In the gas plant in order to realize 100 B.t.u. at the bus-bars, 465 B.t.u. have to be charged into the producer. From a series of tests of a number of different Illinois coals, a comparison of the quantity of fuel for h.p-hr. required in the steam plant and in the producer gas plant at the Bureau of Mines showed that on the average the former required 2.6 times as much as the latter. The author gives detailed data of the distribution of heat in typical steam and gas plants and passes then to the description of the main types of gas producers now in use such as the suction type, the up-draft pressure type, the down-draft type and the double zone type.

INSTITUTION OF ELECTRICAL ENGINEERS

Journal, vol. 52, no. 236, June 15, 1914, London

The Bonecourt Boiler, C. D. McCourt (11 pp., 7 figs.). The article describes what is known as the Bonecourt Boiler which is a surface combustion boiler. The combustible gas and air in the proportions theoretically required for complete combustion are intimately mixed together so as to produce a homogeneous gaseous medium which is then delivered at a high speed into a bed of refractory material on the surface of which combustion takes place flamelessly. As such a mixture of gas and air is explosive, it has to be supplied to the granular bed at a speed greater than the speed at which the mixture will ignite in a backward direction. It is found that with a combustion proceeding in this way, the proximity of water cooled surfaces has no hindering effect on it and it is possible to arrange the granular bed in relation to the water space as to obtain the maximum possible proximity of the water to the heat zone. As it is more convenient to pack the interiors of the tubes with refractory granules than to surround water tubes with these granules, the multitubular type of boiler was the one to which this system has first been applied. The boiler tubes are closed at their entrance ends by fire-clay plugs having holes through which the gas mixture passes. The holes are of

such cross-section that the speed of flow of the mixture is greater than its speed of ignition. In order to cause the gas mixture to pass through the apertures in the fire-clay plugs with the required speed and to enable the products of combustion to overcome the resistance offered by the refractory packing in the boiler tubes, it is necessary to maintain a certain difference of pressure between the opposite ends of the boiler tubes. The amount of this pressure difference required will depend upon the rate of evaporation. In general, the pressure difference of 15 in. of water gage will suffice for an evaporation of 20 lb. of water from and at 212 deg. fahr. per sq. ft. of heating surface per hr. With an increase of the pressure difference, the evaporation likewise increases and it is found that the evaporation produced is proportional to the square root of the pressure difference which is applied. This pressure difference can be obtained in one of two ways, either by supplying the mixture to the boiler tubes under a positive pressure or by drawing away the products of combustion at the exit ends of the boiler tubes by means of a single fan.

As regards the process which takes place in a boiler tube of this type of boiler, it appears that the temperature in the granular packing at the entrance or firing end of the tube will approximate the calorific intensity of the gas employed. With coal-gas or coke-oven gas, the temperature at this point is in the neighborhood of 1800 deg. cent. (3272 deg. fahr.). This is the temperature in the center of the cross-section while the temperature of the granules in contact with the tube surface is very much lower so that the granular packing is red-hot or white-hot at the firing end, but its temperature decreases very rapidly along the tube. The functions of the granular packing are as follows: in the first place, the red-hot granules serve to insure absolute completion of combustion even in the absence of any air in excess of the theoretical requirements; in the second place, they radiate heat to the sides of the containing tube, thus largely accounting for the larger rate of heat transmission obtained, and in the third place, the granules even in that part of the tube where the temperature is so low as to prevent heat being communicated to any noticeable extent by radiation, serve to baffle the combustion products and hurl them rapidly and with violence against the tube walls, thus increasing the heat transmission through the fact of the hot gases impinging on the tube surface. For a given kind of packing in the tubes, there must be provided a definite ratio between the length and bore of the tubes in order to obtain sufficient cooling of the combustion gases. If it is desired to employ longer tubes of the same bore, this may be done without sacrificing considerations of economy by employing a packing material of a more open nature in the tubes. As regards heat losses in the boiler, several sources of these appearing in solid fuel boilers do not have to be considered in the surface combustion type, and in a Bonecourt type the combustion products leave the system at the temperature of about 110 deg. cent. (230 deg. fahr.), where a feed-water heater is employed so that the amount of heat carried away by the waste gases is very small, while owing to the compactness of the plant, the radiation loss is also small, amounting to about about two per cent. It appears therefore, that the heat utilized in steam generation varies from 94 to 95 per cent of the heat originally available in the gas burned.

The author describes in some detail the plan where this type of boiler is used as a link in the system of generating power from coal by means of ammonia recovery gas producers. In the described plant, conditions were established so that an expensive fuel such as the illuminating gas of London is advantageously employed for steam generation. The boiler is 8 ft. long and 3 ft. 6 in. in diameter and is provided with five tubes, each of 6 in. bore. It is capable of evaporating about 2000 lb. of water per hr., and is used for supplying steam to a steam hammer. The advantages of using this type are the readiness with which steam can be raised when wanted for the hammer and the immediate manner in which the making of steam responds to the turning on and off of the gas. A novel type of construction has been adopted for this boiler. The tubes instead of being of uniform bore throughout contract sharply at the entrance end, the first 6 in. of the tubes being only of such bore as is required for the supply of the gas mixture. This type of construction permits of dispensing with the use of the fire-clay plugs and the first part of the tube which conveys the gas to the fire-clay packing and is kept cool by the water in the boiler. The author states by the way that granular packing may be employed for the purpose of increasing heat transmission in so-called waste heat boilers where the heating medium consists of products of combustion from a furnace or gas engine. There is, of course, no surface combustion in the tubes of this kind of boiler as the granular packing serves merely to increase the heat transmission through the walls of the tube by radiating heat from the hot granules and also by causing the hot gases to impinge repeatedly on the tube walls. In addition to the gaseous fuel or hot waste gases, Bonecourt boilers can be fired also with liquid fuel. In this case practically the same processes occur, since the combustion of liquid fuel is only a special case of gaseous combustion: when liquid fuel burns, it is really the combustible vapors given off by it that are burned. But special methods for securing complete combustion of liquid fuel in contact with or in close proximity to water cooled surfaces have to be developed for this purpose. The boiler which is now used in the works of Bonecourt Surface Combustion, Ltd., in London is 5 ft. in diameter and 12 ft. long and is furnished with five boiler tubes, each 9 in. bore. The boiler tubes are packed with refractory material arranged on the staggered plan. The liquid fuel is supplied to the boiler tubes under the pressure due to a head of about 12 ft. The air required for the combustion is supplied from a fan at the pressure of from 5 to 30 in. water gage, the oil being spread by the air. There is at the entrance of each boiler tube, a gasification chamber for the spray of liquid fuel. The purpose of this chamber is to gasify or at least to partly gasify the liquid fuel. This gasification is brought about by the heat of the chamber and the partial combustion of the liquid fuel which later serves to maintain the chamber at the required temperature. The chamber is far too small to enable complete combustion of the fuel to take place. The following are the results of a test carried out on the oil-fired boiler referred to at the London Works of the Bonecourt Company:

Steam pressure, gage (per sq. in.)	110 lb.
Temperature of oil	80 deg. fahr. (27 deg. cent.)
Air pressure	37 in. of water
Pressure in smoke-box	3 in. of water
Temperature of combustion products leaving boiler tubes and entering feed-water heater	608 deg. fahr. (320 deg. cent.)

Temperature of combustion products leaving feed-water heater	275 deg. fahr. (135 deg. cent.)
Temperature of cold feed	43 deg. fahr. (6 deg. cent.)
Temperature of feed from feed-water heater to boiler	119 deg. fahr. (48 deg. cent.)
Duration of test	3 hr.
Total water evaporated	7,625 lb.
Water evaporated per hr.	2,542 lb.
Water evaporated per hr. from and at 212 deg. fahr.	3,085 lb.
Total tube surface (five tubes 9-in. bore 12 ft. long)	141 sq. ft.
Total heating surface of boiler	123.7 sq. ft.
Steam raised per sq. ft. of heating surface per hr. from and at 212 deg. fahr.	25 lb.
Total oil burned	545 lb.
Oil burned per hr.	181.7 lb.
Water evaporated from and at 212 deg. fahr. per lb. of oil	17.0 lb.
Net calorific value of oil (per lb.)	17,800 B.T.U.'s

$$\text{Efficiency} = \frac{7625 \times 1175.9 \times 100}{545 \times 17800} = 92.5 \text{ per cent}$$

A continuous sample of the combustion products was taken during the test, and was found to analyze:

	Per cent
Carbon-dioxide	12.8
Oxygen	3.4
Carbon-monoxide	0.0
Nitrogen	83.8
	100.0

The points which characterize this boiler may be enumerated as follows:

1. Complete combustion of the oil, no products of partial combustion being found in the flue gases.

2. The air required for complete combustion of the oil is only slightly in excess of the theoretical requirement.

3. Entire absence of smoke when once the boiler has been started up, and practically no smoke while starting.

4. The oil is supplied to the boiler cold and at a very low pressure, the air supplied for the combustion being sufficient to effect the necessary spraying of the oil.

5. The combustion products are cooled down to a point below which further cooling would scarcely be practicable or economical.

6. An evaporation of 25 lb. of water per sq. ft. of heating surface per hr.

7. The effective transmission to the water in the boiler of 92.5 per cent of the net heat available in the oil burned, even when evaporating at the above stated high rate.

8. Exact and immediate regulation of steam production.

RAILWAY CLUB OF PITTSBURGH

Vol. 15, no. 7, May 22, 1914, Pittsburgh, Pa.

Some Ill Effects of Boiler Feed Waters and Their Causes, W. A. Converse (40 pp., 30 fig. d). The article presents a very comprehensive discussion of ill effects of boiler feed waters and their causes covering both the theory of boiler scale formation and corrosion and some of the practice. The author gives also a number of analyses of boiler feed water and discusses the action of such waters in the light thrown on its composition by the analytical data. Thus, in one case he finds that water containing quite a large amount of carbonate of soda (22.789 grains per gal.) produced a deleterious effect on the condition of the gaskets. He explains that this was due to the fact that the gaskets upon the market to-day are largely made up either of asbestos or asbestos composition or of rubber or rubber composition, both of which are to a large extent soluble in strong alkaline solutions. Control experiments have been made and have shown that no such troubles are experienced where water is used containing practically the same amounts of the substances other than the soda salts. In another analysis, a large amount of sulphate of lime (44.989 grains per gal.) was found. The water gave rise to strong formation of scale and in addition produced serious corrosion underneath the scale. This is an interesting fact because it is not uncommon to find that an assumption is made to the effect that boiler scale protects the metal from corrosion. This may be true in most cases but in the present instance, it was found that under the layer of the scale, there was an action going on identically similar to that of sulphuric acid upon iron. The water itself, however, was not acid and contained no free sulphuric acid which consequently must have been a liberated product. It would appear from the investigation thus far carried on that the sulphate of lime which constituted the greater part of the scale decomposed at a temperature reached when the scale had become of sufficient thickness. Sulphur was liberated and attacked metallic iron. The sulphate of iron formed as the result of initial corrosion being a very unstable salt, broke down under the action of temperature and moisture, and again liberated sulphuric acid, leaving behind the iron in the form of iron oxide. A cyclic or continuous action took place therefore, and a comparatively small amount of sulphuric acid produced a very large amount of corrosion. The proof that the process occurred substantially as above described could be obtained by taking into consideration that sulphate of lime does not break up below a certain temperature. When accordingly, by means of mechanical devices, the scale formation in the boiler in which the experiment was carried on, was turbined down to half its original thickness and kept at it, it was found that no corrosion underneath the scale formation took place as the temperature at the point of contact was kept below the limit of liberation of sulphuric acid.

In the next analysis, a comparatively large amount of suspended matter was found with accompanying foaming when the water was used in the boiler. An experiment was carried on for the purpose of determining whether or not the foaming was due to the presence of precipitated carbonates. The feed water was treated in such a manner as to remove about one half of the carbonates of lime and magnesia, shown by analysis, and then pumped into the boiler; it was found that it was possible to operate the boiler over a period of 60 days with no trouble from foaming. Further experiments developed the fact that the same results could be obtained by changing the carbonates into other substances by chemical reaction at a much lower cost. The analysis in the same instance developed that the presence of black putty-like substance in the cylinders of the engine was due to the presence of carbonates of lime and magnesia in the water since this substance was nothing but a mixture of such carbonates with cylinder oil. Since oil itself carried none of them, the only way for them to reach the cylinders was by being carried over mechanically with the steam. This trouble

can also be overcome by changing the nature of the precipitated substances by chemical reaction.

The author presents further analyses which confirm the contention that ill effects of water are not exclusively attributable to the quantities of substances contained, but more particularly to their relative amounts. In two cases, water contained considerable amounts of chloride of magnesia. In one case, there was a serious corrosion above the water line, in another, there was none. The former was clearly due to the decomposition of the chloride of magnesia and formation of a very dilute solution of hydrochloric acid, while in the second case, corrosion did not occur because along with the chloride of magnesia there was a considerable amount of carbonate of lime present which combined with the hydrochloric acid liberated, and produced chloride of lime. In other words, there may be in the water substances neutralizing the injurious action of other substances present.

Further analysis establishes the interesting fact that water may contain very small amounts of total solid matter and still be entirely unfitted for the duties of boiler feed water. Water containing 1.8 grains per gal. of total solid matter, or apparently an ideal water for boiler purposes, was used in a stationary plant with the result that it was found necessary to replace the cold water portion once in every six or seven months while no corrosion took place in the boiler. An investigation was carried out by taking four samples of water from the original source of supply near the inlet to the pipe system, near the outlet of the system, and from the pet-cock at the bottom of the water column. The analysis showed that the quantity of iron contained in sample from near the inlet corresponded with that contained in the sample from original source but in the sample from near the outlet, two and a half times as much iron was found which showed conclusively that the water dissolved iron in passing through the pipe system. In the case of the sample from the boiler, there was found a large amount of iron held in suspension but the same amount in solution as was found in the sample taken from near the outlet of the cold water system which showed that in passing through the pipe in question, the water had taken up as much iron as it could hold in solution and did not exert a corrosive action on the boiler on account of it being already saturated. The author passes then to a discussion of the ionic theory of solutions and its bearing on corrosion in boilers.

In the discussion which followed, the question was brought up as to pitting of locomotive boilers which had been taken out of service, drained and set aside for a considerable time. Locomotives which had been set aside and filled with water remained in perfect condition at the end of the same period. The speaker explained that there was possibly greater action of free oxygen when the boiler was left open with air circulating through it. Another condition that might govern in this case is the permeation of the air in the empty boiler with sulphur gases always present in the atmosphere about shops where much coal is used as a fuel. It is, therefore, as a general rule, a much safer plan to keep boilers filled with water rather than leave them empty.

ROYAL SOCIETY

Proceedings, Series A, vol. 90, no. A 619, July 1, 1914, London

On the Flow of Metals under Large Constant Stresses, E. N. da C. Andrade (15 pp., 5 figs. *e*). The article presents the data of a research having for its object the examination of the general laws of flow in metallic wires when extended so as to cover the region of large permanent set by stresses kept constant throughout the flow. One of the purposes of the investigation was to see if very pure metals behaved in the same way as commercial metals, and whether it was true that the non-viscous character of the initial part of the extension time curve was due to impurities. In the course of the research a type of flow not hereto observed was found. To test the flow under constant stress, the device of the hyperbolic weight was employed; by the use of such a weight sinking as the wire stretched into a liquid of suitable density, the effective load was diminished in such a way that the stress over the cross section remained constant as the wire thinned. All the metals investigated except mercury were used in the form of wire while for mercury a special method was resorted to. The iron and copper wires were carefully annealed, and after this treatment gave consistent results. It was found that without exception all the single metals (not alloys) gave at the various temperatures investigated, curves of extension against time which could be closely represented by the formulæ:

$$l = l_o \left(1 + \beta t^{\frac{1}{3}}\right) e^{kt}$$

by assigning suitable values to the constants. The constants l_o, β, and k are not purely artificial but have a physical processes corresponding to each one of them; that is l_o represents the immediate length of loading, β is the coefficient which gives a measure of that part of flow whose rate decreases as the time increases, and k measures the final flow which proceeds viscously.

The curves for iron at 444 deg. cent. resembled those for lead at 16 deg. cent. and there was no difference of type. The main result of this part of the work was to show that typical metals of widely different nature obeyed the same general laws of flow and that the apparent difference of type disappeared when a wide range of temperature was considered. The higher the temperature for a given metal, the more the viscous type of flow predominated. Small impurities did not affect the general type of extension curves and pure mercury at — 78 deg. cent. had much the same curves as soft commercial iron at 444 deg. cent. It has been further shown that for metals the flow tended to become in every case finally viscous and an investigation was made to discover if possible what change was produced in the metal which sets it in a condition to flow viscously and how the change could be effected. It was found that by extending the wire rapidly under a large stress for a short time it could be put in a condition to flow viscously from the start when subject to a smaller stress. The more rapid the preliminary extension, the smaller the rate of the viscous flow under the subsequent smaller stress. It has also been found that severe preliminary twisting would put the wire in a state to give the viscous flow almost from the start. With increasing amount of preliminary twist, the rate of flow first of all decreased, but reached a minimum, and then increased slowly, probably owing to tears in the metal. A twist of a given number of turns was more effective in hardening the metal if it was applied half in the one direction and then half in the other than if it were applied all in one direction.

FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

EFFECT OF THE WAR ON FOREIGN PERIODICALS

The war in Europe has wrought sad havoc with the files of foreign periodicals in the Library of the Engineering Societies. The English, Italian and Scandinavian periodicals come in with fair regularity, and with practically their usual number of pages. The German periodicals have been either discontinued (as the Werkstattstechnik announced, because "nobody cares to read trade papers now"), or are issued in reduced sizes, and delivered with great irregularity. The Belgian papers, published at Louvain and Brussels, have been discontinued for obvious reasons. The French papers have been so far coming in regularly, but sometimes in reduced sizes. No Russian papers have come in since the beginning of the war, although regularly issued. No Austrian papers have been received, and no information as to their being issued is available. Notwithstanding all these circumstances, enough material is available to carry on the work of the Engineering Survey in the usual manner.

THE VALUE OF THE ENGINEERING SURVEY TO STUDENTS

Now that a new school year begins, it may be in order to call to the attention of future engineers in our colleges the benefits which they may derive from getting into the habit of looking over every month the Engineering Survey in *The Journal*. During their freshman and sophomore years they will probably find a good deal that will be somewhat beyond their depth, but even then a number of articles will be such that they can readily understand. A junior in either mechanical or electrical engineering ought to be able to understand the gist of nearly every article. What a student can learn from a perusal of the Engineering Survey month after month is, first, the general tendencies of modern invention both in Europe and in this country; second, the point of view taken by prominent designers here and abroad in the selection of their engineering equipment; and finally he will learn the names of the periodicals and publications of societies where information on various subjects may be found. When it comes to writing his thesis, and especially when after graduating from college he happens to run across some work of design along individual lines, he will find the ability to look with some certainty for information in the more or less out of the way periodicals—an advantage of inestimable value. There are good engineers in countries and localities of which the ordinary engineer thinks very little: in China, Australia, South Africa, Chile. These engineers run across peculiar problems and often solve in special ways, the knowledge of which may be of the greatest possible value to the American engineer when *he* gets into a similar tight place. The Engineering Survey, within the space available, is doing its best to present all such information in as clear and readable a manner as possible, and the engineering student, who makes a habit of reading it over as it comes out, will soon find that a lot of the information which he gets from it, sticks, and can be used even in his work at college.

THIS MONTH'S ARTICLES

In the section Aeronautics is given an abstract of a paper by Professor Ch. Maurain on the progress of experimental work in aeronautical engineering, especially interesting at the present time when the events in Europe have directed serious attention to aircraft as a means of national defense. The abstract, among other things, contains a list of European aeronautical laboratories.

The next article gives data on endurance tests of heavy automobile trucks. The section on Internal Combustion Engineering goes into considerable detail concerning the use of explosion engines in railway work, such as branch lines and for light trains on secondary lines. Particular attention is paid to the problem of power recuperation during the downgrade runs or slowing up of trains. In the section Steam Engineering are described a German triple-flue boiler plant and a new evaporation apparatus for the production of distilled water in which a part of the steam of evaporation is compressed by live steam and takes further part in the process of evaporation.

Two papers before the American Foundrymen's Association are devoted to the discussion of the influence of the skin on the strength and ductility of malleable cast iron (Touceda), and to the elimination of waste motion in bench molding (Kennedy and Pendleton). In the former paper data of tests on the strength of machined and unmachined test wedges of malleable cast iron are reported, and certain ideas on the importance of the skin are combated. From the Bulletin of the American Institute of Mining Engineers are abstracted several interesting papers: on nodulizing flue dust which may be of interest to those engineers who have to work with blast furnace gases for heat engines and boiler firing; on the annealing of cold rolled copper; and on surface decarbonization of tool steel. The last paper contains an interesting explanation as to why the "bark" on tool steel is so hard on machining tools.

Marshall R. Pugh, before the American Society of Civil Engineers, presented a comprehensive discussion of external corrosion of cast iron pipe, a subject which has been of late attracting considerable attention both in this country and abroad. From the Journal of the American Society of Naval Engineers is taken an abstract of the account of the work of the U. S. Navy Engineering Experiment Station, containing among other things data on the compound issued to the service for rendering boiler materials non-corrosive.

From the Transactions of the Canadian Society of Civil Engineers are taken data on concrete stack construction and on disregarded stresses in joints and ends of steel in reinforced concrete construction.

An interesting consideration of pitot tube formulae, and data of tests of pitot tubes and two different types of current meters, as applied to the measurement of large volumes of water flowing at variable velocities, are presented in the abstract of a paper of B. F. Groat before the Engineers' Society of Western Pennsylvania, and an equally interesting paper (by Gerald Stoney) on high speed bearings, and several subjects closely associated with this subject, such as oil-

cooling, is reported from the Transactions of the North-East Coast Institution of Engineers and Shipbuilders.

FOREIGN REVIEW

Aeronautics

Review of Experimental Work in Aeronautical Engineering (*Revue d'aérotechnique expérimentale,* Professor Ch. Maurain, *Revue générale des sciences,* vol. 25, no. 14, p. 679, July 30, 1914, 8 pp., *tg*). The present article gives a review of the work lately done in the great aeronautical laboratories of Europe and America. In France the military laboratories continue the splendid work started years ago by Colonel Renard. In addition to that, there are several extremely well-equipped civilian laboratories, such as the well-known laboratory of Mr. Eiffel, the laboratory of the Duke of Guiche, who uses the special method for recording photographically pressures and partial depressions existing at the same instant at different points of surfaces or other parts carried on specially equipped automobiles. The Aeronautical Institute of the University of Paris, founded by Deutsch de la Meurthe, uses several methods simultaneously, such as the dynamometric car, rotating arm, air tunnel and measurements in actual flights. In Russia, the laboratory of Koochino, started by a private scientist, Mr. Ribooshinsky, has for many years carried on various experiments on surfaces and propellers by means of an air tunnel. Other aerodynamic investigations are being carried on in the laboratories of several of the technical schools; those of the University of Moscow, under the direction of Professor Joukowsky, deserve special mention. In Germany, the laboratory of the University of Göttingen, under the direction of Professor Prandtl, has been for several years using the method of air tunnel and rendered valuable service to the art of aviation. Another well-equipped laboratory has recently been installed at Aldershof (under the direction of F. Bendemann, of the German Institution for Experimentation in Aviation), the chief purpose of which is the test of motor propeller sets, although a wider field of experimentation is under contemplation for the future. Valuable measurements on propeller action have been made at Frankfort by means of the dynamometric car. In addition to that there is the aerodynamic laboratory of the Berlin technical high school, under the direction of Major von Parseval, while in Austria, an aerodynamic laboratory has been installed in connection with the technical high school of Vienna, under the direction of W. von Doblhoff. In Italy the military laboratory of aerodynamics at Rome is under the direction of Crocco, and has published several important researches on aerodynamics and hydrodynamics. All aerodynamic experiments are made by the method of air tunnel, while the hydrodynamic experiments are made in an experimental tank, with a towing car. In England a special committee has been appointed for research in connection with aeronautics under the chairmanship of Lord Rayleigh, the actual work being done at the National Physical Laboratory at Teddington by the method of air tunnel and, for propellers, by rotating arm. This work is carried on in such a manner as to collaborate with either civil or military laboratories, in particular that of the Royal Aircraft Manufacture.

The work of these laboratories is not always systematic, which is due mainly to the fact that the extremely rapid development of aviation made it necessary to find immediate answers to practical questions instead of taking up more general questions of scientific interest. The degree of precision of the various methods of measurements has not yet been fully established, and each laboratory being equipped preferably for a certain kind of measurements, is doing the work which it is best able to do, without often attaching too much value to the absolute worth of the results obtained. It will require long and delicate comparisons between the results obtained by the various methods to establish answers to the most important general problems.

The author proceeds to describe in a general manner experimental investigations having for their purpose the determination of the general laws of flight, such as, for example, the supporting action of air as a function of the relative velocity of the plane and density of air, and the investigations made to determine the value of the coefficient K used in this formula. A large amount of investigation has been devoted to the study of the numerical relations in the action of air on aeroplanes, so as to determine the velocity and position of such action for various inclinations of the planes as functions of the relative velocities, and for various positions of the vertical rudder with respect to the main planes. The data collected already enable us to solve a number of important problems, e.g., to calculate the conditions of equilibrium of an aeroplane, to construct a metacentric curve and to deduce the conditions of stability. These investigations have had an especially important bearing on the study of stability of aeroplanes. G. de Bothézat has shown by the method of small motions applied to an aeroplane in still air, that if the aeroplane be assumed to be non-deformable, it will be stable longitudinally, but that it will remain inherently unstable laterally. By stability is meant the ability of the aeroplane to resume its normal position after having been, by whatever cause, slightly brought out of it. While these results are of considerable theoretical interest, it must be remembered that in practice the important point is to secure stability not in still air but in gusts. In practice also, aeroplanes are not non-deformable systems. The pilot intervenes all the time with a view of reestablishing, by means of his rudders or ailerons, the equilibrium disturbed by the movements in the atmosphere, and the conditions which must particularly be realized in the design of a machine consist in proportioning the efficiency of the means of governing to the amplitude which the violent disturbances of the atmosphere may produce in the action of the planes, so as to permit the pilot at all times to remain master of his apparatus. The methods of computation based on the general principle of small motions do not indicate what may happen during violent atmospheric disturbances, and it is here that the great value of the excellent methods of registering the relative velocity of the aeroplane, its inclination, inclination of its trajectory, movements of the governing devices, etc., introduced by Toussaint, and Lepère and Gouin, come into play. It is significant that the school of aviators, represented by men like Blériot, believe that the security in aviation can be realized by making aeroplanes extremely easy to manage, so that the pilot may without difficulty execute the most complicated movements without losing control of his machine. When he happens, therefore, to meet violent atmospheric disturbances, these disturbances produce variations of flight, but only such as he has been in the habit of creating himself. This is correct, with the restriction, however, that it requires a flight at a considerable elevation,

since nearly all evolutions in the aeroplane involve loss of height, as flights near the ground during a strong and irregular wind appear to be especially dangerous to a light machine.

The second part of the article reviews the experimental work done on aerial propellers. From a practical point of view, it is important to note that it is possible to determine now the characteristics of propellers working not only as fans but while in motion at a certain speed. Aerial propellers have already reached maximum efficiencies of from 70 to 80 per cent and sometimes have exceeded this value. The author believes that with the present-day propellers and explosion motors, helicopters have already become possible, but will have no practical application until some method has been found to prevent the fall of the machine if the engine becomes stalled. It is, however, possible that the combination of helicopters and aeroplanes may bring about the realization of the dream of large aerial vessels easily governed and perfectly stable.

Automobiles

Military Endurance Tests of Automobile Trucks (*L'epreuve militaire d'endurance des automobiles de poids lourds, du 1er au 30 juillet 1914*, Duroc, *Le Génie Civil*, vol. 55, no. 15, p. 289, August 8, 1914, 5 pp., 16 figs., *de*). The article gives some data on the practical endurance tests of heavy motor trucks carried out in France during July 1914. The original program of the tests contemplated runs from July 1 to August 4 of 100 km. every day for tractors and 150 km. per day for motor trucks, with a final examination to be made between August 5 and August 8. The declaration of war compelled the commission, on July 30, to release all the trucks from the test and to pronounce 60 out of the 66 trucks as having satisfied all conditions.

There were, in the performance of these tests, certain particulars worthy of notice. For example, contrary to the method of performing the tests adopted in 1913, all the runs this time were made along roads converging, star fashion, to the city of Versailles, so that every day the cars started from that city and returned to it at night. While in this way the demonstration of the motor trucks under test in various provincial cities, with its corresponding advertising advantages, has been omitted, there is no doubt but that the cost of the test to the manufacturers has been very materially reduced and the observations by the authorities were, to an equal degree, simplified.

The military commission and the war office have made the following regulations for the present tests:

The gross weight of the truck of 3500 kg. does not include tools, spare parts and driver, the rear axle thus being permitted to carry a load up to 5000 kg. The engine must be placed under wood, which is reasonable, because it makes it more accessible and easier to inspect.

Sixty-six trucks have actually entered the competition. The engines of all the four-cylinder vertical type have a volume swept over by the piston of 4.500 liters which corresponds at a speed of 1200 r.p.m. to an average h.p. on the testing stand of 28.30 h.p.

Internal-Combustion Engineering

Traction by Thermal Engines on Railways (*La traction par moteurs thermiques sur voies ferrées*, L. Saint-Martin, *Bulletin mensuel de la Société Belge des Electriciens*, vol. 31, p. 485, July 1914, 80 pp., 8 figs., *dge*). The article presents an extensive discussion of the various forms of motive power for railroads, such as steam locomotives, electric locomotives and internal combustion locomotives. In connection with the latter, the author discusses in considerable detail the internal combustion locomotive with an auxiliary electric drive such as is represented by the H. Pieper system (compare *The Journal*, March 1913, p. 532). It is a well-known fact that the maximum power developed by an internal-combustion engine approaches very closely the most economical power at which it can be operated so that an internal-combustion locomotive set does not easily adapt itself to taking up overloads. The Pieper system provides for such emergencies by combining with the internal-combustion engine an electric unit which may be used either as a generator or as a motor, and a set of storage batteries. When the entire power of the engine is not utilized for purposes of direct propulsion, the reserve is taken up by the dynamo which then acts as a generator and charges the storage batteries. On the other hand, when an overload is brought on the engine, the batteries discharge through the dynamo, which acts as a motor and boosts the engine action. This is what the author calls a "buffer" system.

One of the interesting parts of this type of drive is the fact that it appears to present an elegant solution of the problem of power recuperation. There have been a good many systems proposed for recuperation of power loss during the down-grade runs and in slowing-up, but the numerous devices so far proposed have proved to be failures. It is only in storage battery cars, e.g., on the tramway line from Paris to Saint Denis, that as much as 10 to 14 per cent of the total power has been recuperated. This, however, is of little practical importance on account of the limited use of the storage battery cars.

Numerous tests have also been made on mountain electric railway lines where an effort was made to drive the motor as a generator during the down-grade run and return the current thus generated to the central station. In order, however, that this might be possible, the generator has to deliver current at a higher voltage than the one existing at the line contact, and when a single phase motor is used, this can be achieved only by an application of special transformers. Direct current motor traction also lends itself but poorly to power recuperation. On the other hand, in thermo-electric systems of drive, with an electric buffer system, recuperation of energy, owing to the reversibility of the buffer dynamo, is extremely easy. When the car runs down an incline, the speed of the engine tends to increase, and the voltage of the dynamo increasing likewise and becoming superior to the voltage of the storage battery, produces an automatic flow of energy from the dynamo into the battery. If at the same time in some way, such as by an automatic application of a solenoid governor, the supply of fuel to the motor be cut off, then the kinetic energy liberated at the rim on account of the downward run, is sent into the storage batteries by means of the dynamo, a direct transmission, i.e., with an efficiency of at least 80 per cent. The same thing happens during the slowing up with the kinetic energy resulting from inertia of the car. It must be further borne in mind that this recuperation does not require any supplementary installations on the car, but automatically follows from the operation of the motive and governor elements of the driving plant, the only duty of the motorman

being to keep the controller in such a position as to maintain the schedule speed of the car.

The author appreciates the importance of the recuperation of energy which may be obtained with thermo-electric cars provided with an electric buffer, and considers as an example a line 4 km. long with an average amount of irregular ground so that, say, ½ of the length is flat while the other contains uneven ground, in spots, down grade of an average fall of about 30 mils. The total gradient of these parts of the line, downwards, will be $2000 \times 0.030 = 60$ m.

Assuming now that the average coefficient of traction for the motor car and trailers is 8 kg. per ton (16 lb. per short ton), and that it is necessary to drive on this line a train of 40 tons (44 short tons), including the motor car, with an average speed of 50 km. per hour and at a minimum speed of 25 km. per hour on the above defined inclines. Then the power at the wheel rim is:

On flat ground:

$$P = \frac{(40 \times 8)50{,}000}{3600 \times 75} = 60 \text{ h.p. (in round figures)}.$$

On the incline (30 mils):

$$P = \frac{(40 \times 38)25{,}000}{3600 \times 75} = 140 \text{ h.p.}$$

In order to be able to perform the work to meet the above requirements with an electric transmission motor car having an efficiency of 60 per cent, it would be necessary to have an engine of about 240 h.p., which on the even ground, i.e., over ½ of the total run, would have to deliver only about 100 effective h.p., or about 60 h.p. at the rim. With a car provided with electric buffer dynamo, an engine of 120 h.p. would prove fully sufficient, the additional power required on the heavy up grades being supplied by the storage batteries. It is evident that in this case, the internal-combustion engine will be utilized to much greater advantage than in the case of the first, since its normal output would be close to the average output required by the line conditions.

The author's calculation (not suitable for abstracting) establishes the remarkable fact that energy recuperation during slowing up is practically twice the energy recuperation during down-grade runs, which shows that the use of the internal-combustion engine drive with buffer dynamo is of value not only on lines of irregular ground, but also on lines where frequent stopping or slowing down is required. It is a well-known fact that such slowing down operations are quite frequent even on trunk lines. His figures show that the net recuperation at the rim will be, under the normal conditions of operation assumed, about 28 per cent of the total power necessary for starting and traction purposes. The author discusses further in detail the problem of the use of the storage battery on such cars and the various fuels that may be used. He considers also the cost of operating the cars and gives a table showing the work required per ton-km. under various conditions and amount of standard fuel consumed. He comes to the final conclusion that even when utilizing comparatively expensive fuels, such as benzol, traction proves to be more economical with internal-combustion engines than steam locomotive, both on branch lines and for light trains on secondary lines of the Belgian trunk systems. From the cost point of view, the internal-combustion locomotive is inferior to the electric traction, but the use of cheaper fuels promises to change this equation in favor of the thermal locomotive. Besides, when the amount of capital employed is taken into account, including depreciation charges of central stations, sub-stations, transmission lines, etc., the difference in the two systems comes down practically to the vanishing point. In addition, it must be remembered that the thermo-electric drive presents the greater advantage of being carried on by independent units exclusively, so that it may be, without loss, placed in service on new lines or adopted by old ones. Further, its use eliminates entirely the many chances of accident which always threaten the operation of complicated electric traction systems and which, when they happen, may put an entire section of the system out of business.

The author believes that in many cases, these advantages will be sufficiently important to compensate for the slight excess in cost of the thermo-electric system of drive over the purely electric. The rest of the article is devoted to a detailed description of the thermo-electric motor car with means for recuperation of energy.

Measuring Apparatus

Optical Amplifying Torsion Meter (*Torsiometro ottico amplificatore*, A. Anastasi, *Rendiconti delle esperienze e degli studi eseguiti nello stabilimento di esperienze e costruzioni aeronautiche del Genio*, vol. 3, no. 2, p. 48, April 30, 1914, 3 pp., 2 figs., *d*). The present article describes an optical torsion meter with amplification. The apparatus belongs to the class of electro-optical torsion meters and has been designed by A. Anastasi, engineer of the Italian military aeronautical laboratory. It consists essentially of two drums, t_e and t_i, one inside the other, with a very small interstice between them. Each one is rigidly affixed to one of the two sections A and B, respectively, of the shaft, the torsion of which it is desired to measure (Fig. 1). The interior drum is provided with a certain number of small slots f_i, parallel to the axis of the shaft and exactly equidistant from one another. The exterior drum is provided with a similar number of helicoidal slots f_e of equal dimensions and as equally equidistant. Inside of both drums is located a luminous source, in this case an electric lamp L, carried on a fixed plane. External to the shaft and parallel to it is located a graduated scale R over which can be moved a telescopic sight O, the axis of which is normal to the axis of the shaft. When the shaft is turned, owing to the presence of the internal illumination and in accordance with the velocity of rotation, one may persistently observe the correspondence of the slots in the external drum with those of the internal drum and the position of the plane of correspondence may be determined by taking sights through a

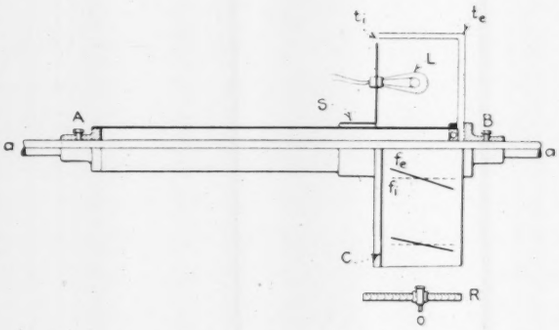


Fig. 1 Optical Torsion Meter with Amplification

telescope. The displacement of such a plane from its normal position of rest is proportional to the torsion of the shaft, or more correctly, to the maximum of the effort transmitted, and can be read correctly on the graduated scale *R*. To this device is added a similar device having for its purpose the amplification, longitudinally, of the relative displacement of the two corresponding points of the two drums, without using any amplifying mechanism. In order to eliminate the perils arising from an eventual shifting of the shaft, it is well to refer the position of the plane of correspondence of the slots not to a fixed origin on the scale article, but to positions on a circle *C*, plotted inside of the external drum.

The above described torsion meter can be used even when the effort transmitted by the shaft is not exactly constant, provided its variations be not too large. In this case, the crossing of the corresponding slots can be seen from the side of the scale, not in the fixed position, but oscillating between two extreme positions between which it is easy to determine a medium point. The apparatus may be conveniently applied at high but not extreme velocities, since the drums with their slots would not be able to withstand a very great centrifugal force. This, however, may be obviated to a certain extent, by using drums made of a light metal, properly disposing

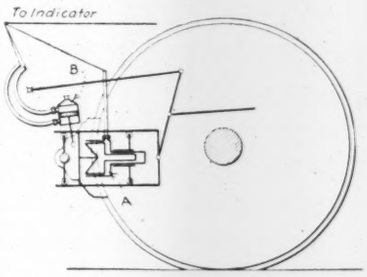


Fig. 2 Brake Action Indicator

the thickness of the material and number of slots, and perhaps reinforcing the entire structure by a helix of steel wire. On the same principle may be constructed the torsion meter comprised instead of two drums, of two discs, one having radial slots and the other a slot made on an archimedean spiral, with a similar lamp and scale arrangement.

Four Axle Dynamometer Car, Swiss Federal Railways (*Vierachsiger Dynamometerwagen der Schweizerischen Bundesbahnen*, H. A. Gaudy, *Schweizerische Bauzeitung*, vol. 64, no. 6, p. 73, August 8, 1914, serial article, *d*). The article describes a four-axle dynamometer car recently built for the use of the Swiss Federal Railways. Among the apparatus with which it is fitted is a device designed by the well-known firm of scientific instrument builders, Brothers Amsler, in Germany, for indicating the braking action and its effects. The apparatus is shown in Fig. 2. For the determination of tangential and radial forces arising through the pressing of the brake shoe against the wheel rim, a hydraulic measuring cylinder is inserted into the rigging. On the front axle of one of the bogies, two such measuring cylinders are built in on the brake hangers of the front brake traversers, while one more measuring cylinder, located horizontally, transmits the brake rigging forces acting on the middle of this traverser. The fluid pressure occurring in these three cylinders during the braking is transmitted to an indicator placed over the apparatus table and recording the pressure diagram on a strip of paper. In this way, two diagrams, one for the tangential and the other for the radial forces, are obtained, and by using the values given by the diagrams, the friction coefficient for any given velocity may be determined.

The same arrangement may be further used for determining from the frictional data obtained above the value of the material used in the brake-shoe. The measurement of the tangential forces may be carried out with the car moving in either direction as there is an arrangement for connecting either end of the measuring cylinder with the recording device. In addition to this device for the measuring of the braking forces in the rigging, there are further provided three indicators for the determination of the air pressure prevailing during the braking process in the main line, the brake cylinder and the auxiliary air tank. While these devices record the pressure diagrams on paper strips, the

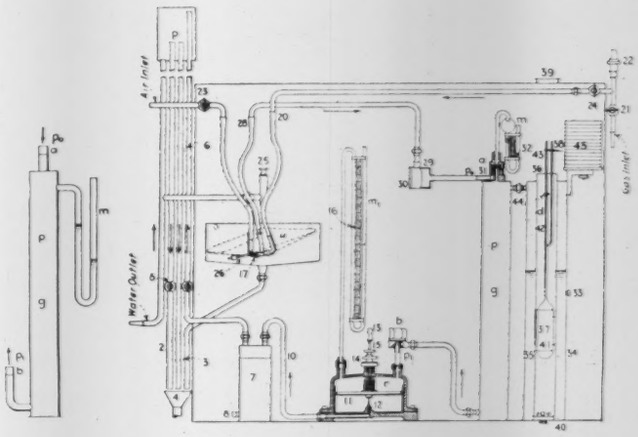


Fig. 3 Densograph

manometers, connected with the indicators, make it possible to read the instantaneous values of the pressure; and two further recording devices take care of the braking length as well as the braking time, the latter being recorded at intervals of 1, 3 and 6 seconds. By means of the above apparatus, the following observations therefore can be taken: (1) pressure in the brake cylinder; (2) pressure in the auxiliary air tank; (3) pressure in the main line; (4) brake-shoe pressure (radial force); (5) tangential force; (6) coefficient of friction of the brake-shoe; (7) time of braking; (8) braking length.

Densograph (*Der Densograph, Professor Hugo Strache, Zeits. des Vereines der Gas- und Wasserfachmänner in Österreich-Ungarn*, vol. 54, no. 10, p. 190, May 15, 1914, 10 pp., 5 figs., *de*). The present article describes a densograph, an apparatus for constant and automatic recording of the specific weight of gases. The usual apparatus for the determination of the specific weight of gases, invented by Schilling, is based on the assumption that the time during which a certain volume of gas flows under a certain pressure through an opening in a thin sheet is proportional to the square root of the specific weight of the gas, but this device, remarkable for its simplicity, has the serious disadvantage of not permitting of making a constant record of the specific weights of the gases and in view of this defect the apparatus

cannot be used for constant records. In addition to that, there is a second very important defect in this apparatus, consisting in that a single observation did not permit of a simultaneous determination of a number of other factors, the knowledge of which would allow of making a clear conception of the processes occurring. There are, of course, a number of apparatus which permit a continuous weighing of gases, but their operation is liable to be interrupted by numerous disturbances from which the densograph is claimed to be safe. It consists (Fig. 3) of the vessel *g*, initially filled with air into which the gas enters through a small plate *a* provided with a tiny opening. The gas is forced through it by means of a suction device and a plate similar to that at *a*, located at *b*. If the same gas passes through *a* and *b*, then the suction inside the vessel is equal to ½ the total suction. If, however, into the air filled vessel there flows a gas lighter than air, then the resistance at *a* will be less and the suction in *g* goes correspondingly down. By this method, a manometer or recording suction meter may be operated; as soon as the gas displaces the entire air and gets as far as *b*, the initial manometer stand will come back. The densograph is made to give a continuous record by including in the apparatus a special device which permits the taking in of gas and air in an established rotation of operations. In addition to the parts shown in the figure, there are several more pumps such as the above mentioned device for sucking in air—a water pump, a governor to regulate the suction of the pump, etc. In order to obtain correct indications it is necessary to maintain the gas and air under equal pressure. The apparatus may be used for coal gas, furnace gas and balloon gases as well as for various other purposes such as the determination of the specific weight of producer gas, etc.

New Apparatus for the Determination of Pressure, Velocity of Flow, Density and Composition of Gases and Vapors (*Neuere Messgeräte zur Bestimmung des Druckes sowie der Geschwindigkeit, Dichte und Zusammensetzung von Gasen und Dämpfen*, E. Stach, *Glückauf*, vol. 50, no. 31, p. 1233, August 1, 1914, 5 pp., 15 figs. *d*). The article describes novel apparatus for the determination of pressure, velocity, density and chemical composition of gases and vapors, including the manometer of Dr. Verbeck, which has vertical tips and two liquids of different densities. The upper parts of the glass tube tips are arranged concentrically in order to avoid possible errors in case the manometer is not placed in an exactly vertical position.

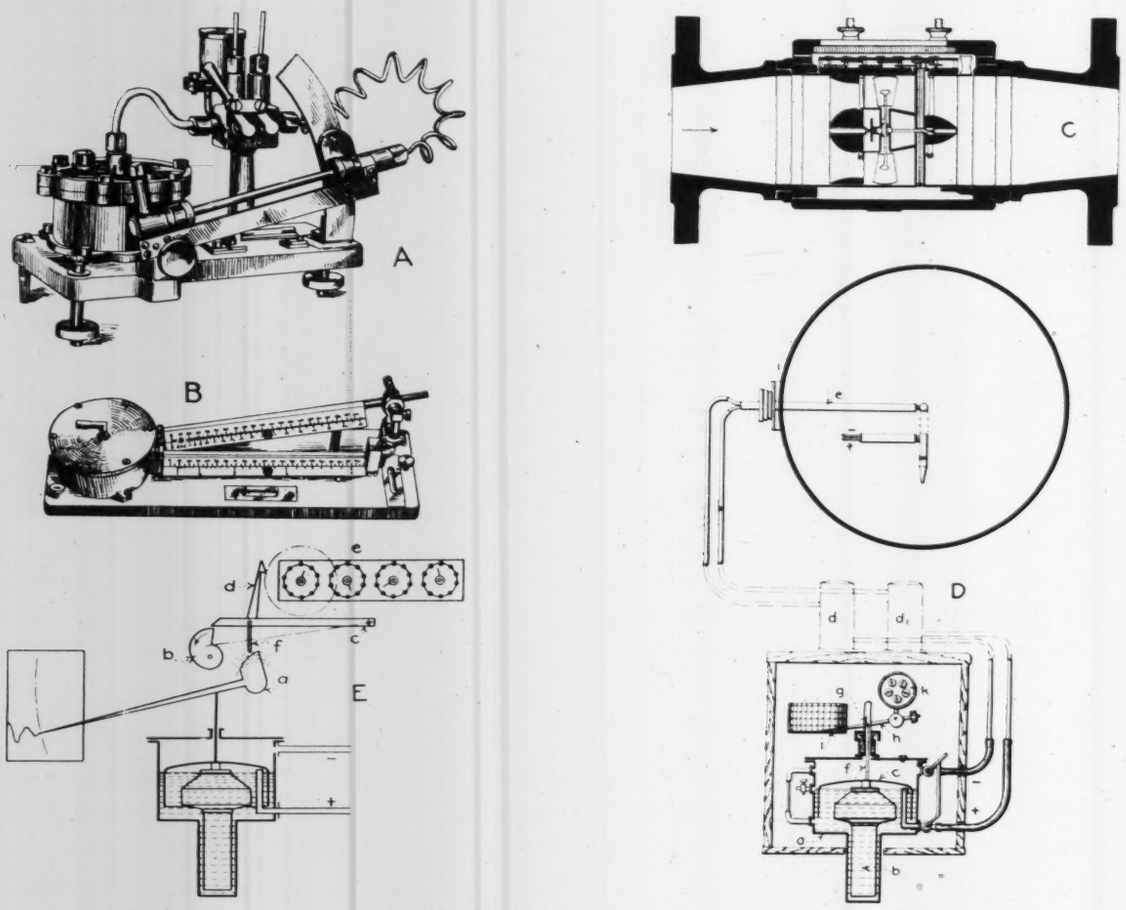


Fig. 4 Various Measuring Apparatus for Gases

As regards micromanometers, Füss builds them now for pressures up to 30 atmospheres, Fig. 4A, with mercury, for measuring pressure of gases and water in closed pipes. In the case of permanently built-in micromanometers with rigidly fixed measuring tubes, there may be a demand for measurements over a wide region of pressures such as cannot be served by a single permanently built-in measuring tube. For this purpose, Rosenmüller has designed the mano-

meter shown in Fig. B, with two permanently built-in measuring tubes covering different regions of pressures, so that when the velocity passes the limits of the upper tube, the lower tube may be used for the measurement. As regards anemometers, only deadbeat types are now used while the improvement of clockwork devices has made clockwork anemometers more reliable and more widely used.

For the measurement of high air velocities such as occur with fans, cup anemometers are often used instead of wing anemometers as being more suitable for this kind of work. For the measurement of compressed air, Rosenmüller builds the wing anemometer shown in Fig. C, which is built-in in a special measuring chamber forming part of the compressed air piping and having an indicating device on the outside.

For recording the velocity of the flow of gas, the arrangement shown in Fig. D, and designed by Füss, is said to be especially convenient, since it has succeeded in using the same scale even for low velocities up to 5 mm. per sec. with a great sensitiveness of indication. In a metal vessel, *a*, there floats in a liquid a specially shaped body *b*, provided with diving bell *c*, which divides in two the air space over the liquid. The spaces thus formed are connected by means of pipes or hose with the air tanks *d* and d_1, which are in their turn connected with the Pitot tube *e*. The large area of the diving bell insures a high sensitiveness of the apparatus while the tapered formation of the head of the float produces an equal rise of the entire structure out of the water. In order to transfer the motion of the float without friction and without the use of any packing, to the recording apparatus, an iron piece *g* is set on a brass spindle *f*, surrounded by a brass pipe, well screwed on to the cover of the device. Around this brass pipe is located a magnet resting on the lever *h*. The stylus *i* then shows the velocity occurring at the instant. By means of the counter device *k*, the amount of gas flowing through the pipe or passage can be read direct.

The clever arrangement of this counter-device is shown in Fig. E. The end of the lever carrying the magnet is provided with a graphite piece *a*, the shape of which has to be established experimentally so as to be in accordance with the section of the measuring tube. A small clockwork arrangement releases at short intervals of time another clockwork device which in its turn releases lever *c*. This allows during the test of the fall of the pawl device *d* of the counter *e*.

And lever *c*, during the period of its fall, actuates the clockwork *e* through the pawl *d*. The motion of *d*, and accordingly the indication of clockwork, depends on the position of the curved piece against which strike the caliper-shaped piece *f*. With gases of constant density and temperature, an agreement as close as 1 per cent has been obtained between measurements by planimeter and the described apparatus.

Steam Engineering

Triple-Flue Boiler Plant (*Eine Dreiflammrohr-Kesselanlage*, Föge, *Zeitschrift für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 33, p. 398, August 14, 1914, 2 pp., 5 figs., *d*). The article describes a triple flue boiler plant installed lately in a textile plant at Linden, Germany. Recently, the former power plant of the factory became insufficient to take care of the increased output, while the limitations of space did not allow of an increase of equipment by installing more units. The only thing that remained therefore was to take out the existing equipment and to put in new units which would, with the same amount of space, produce a substantially larger output of steam. While the use of water tube boilers would solve this problem sufficiently well it could not be resorted to on account of the extremely bad properties of the water in the river Ihme, from which the boiler feedwater was taken. After careful consideration of the situation, the use of very large triple flue boilers was decided upon and units were selected having 155 q.m. heating surface and producing steam at 12 atmospheres pressure, 300 deg. cent. (540 deg. fahr.) super heat, the feedwater being previously preheated to 110 deg. cent. (230 deg. fahr.) in a cast-iron cylinder of the Green type. Fig. 5 shows the way the installation was effected.

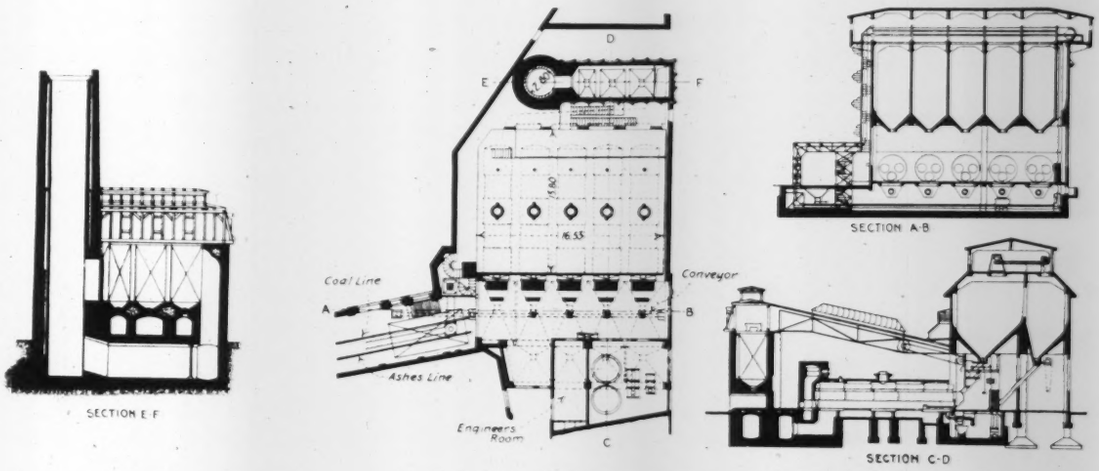


Fig. 5 Triple Flue Boiler Plant

New Evaporation Apparatus for the Production of Distilled Water (*Ein neuer Verdampfapparat zur Erzeugung von distilliertem Wasser*, H. W. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 30, p. 367, July

42, 1914. 1 p., 1 fig. *d*). The article describes a new apparatus for the production of distilled water. The apparatus, built by the Balcke Machine Company of Bochum, Germany, differs from other types now on the market in that it compresses a part of the steam of evaporation by means of live steam and in this way enables the former to take part in the further evaporation process, the compression being effected by means of what the author calls a "thermo-compressor." This is nothing but a steam jet apparatus of peculiar construction, possessing an exceptionally high efficiency, and is the most important part of the apparatus; the latter delivers distilled water ready for actual use.

The general construction of the apparatus is shown in Fig. 6. It consists of the raw water tank *A* and preheater *B*, thermo-compressor *C* and vaporizer *D*, in addition to which there are of course piping, condensers and a wrought iron frame. The vaporizer works by means of live steam which is led on to the thermo-compressor after it has gone through the water separator *W*. A part of the live steam carries over by suction from three to four times its weight of steam from the evaporation chamber *K* of the vaporizer, the compressed steam mixture passing then into the vaporizer chamber *D*. Here the steam mixture is condensed and gives up its heat to the distilled water, which is equivalent to producing from the water to be distilled, an amount equal to its weight of steam of evaporation. If now one part of live steam compresses four parts of steam of evaporation, in five parts by weight of the steam mixture reaching the vaporizer chamber, it will convert five parts by weight of water into a similar weight of steam of evaporation. Out of these five parts, four are carried by suction through the thermo-compressor, conducted into the steam chamber, and there condensed, while the fifth part goes into the preheater *B* and preheats there the entire water which is to be distilled to nearly 100 deg. cent. (212 deg. fahr.). It appears that when water starts with an initial temperature of 10 deg. cent. (50 deg. fahr.), this amount of steam is just sufficient for doing that work. As a result, therefore, the total steam of evaporation is condensed, four parts in effecting further evaporation and one part in the preheater, and the water of condensation, which is in this case also the distillate, is conducted into the storage tank and used for any purposes that may be required.

General Considerations Concerning Condenser Air Pumps (*Considérations générales sur les pompes à air des condenseurs,* A. Delas. *Mémoires de la Société des Ingénieurs Civils de France,* ser. 7, vol. 67, no. 5, May 1914, p. 585. 11 pp., 13 figs. *d*). The article describes various air pumps used in connection with steam turbine plants. It is mainly of historical and descriptive nature and presents general considerations on the construction of apparatus, otherwise well familiar to American engineers, such as the Leblanc rotary jet pump and the Delaporte ejectair (for the latter see *The Journal,* July 1913, p. 1183).

ENGINEERING SOCIETIES

AMERICAN FOUNDRYMEN'S ASSOCIATION

Advance papers of the Annual Meeting in Chicago, September 7-11, 1914.

Remarks on the Strength and Ductility of Malleable Cast Iron After the Skin has been Removed, Enrique Touceda (abstracted)

The Selection of Grinding Wheels for the Foundry, C. F. Dietz

Elimination of Waste Motion in Bench Molding, R. E. Kennedy and J. C. Pendleton

Researches in the Annealing Process for Malleable Castings, Oliver W. Storey

General Melting Characteristics of Acid Steel for Castings, A. F. Stirling Blackwood

Safety and Sanitation in the Brass Foundry, F. Moerl

Remarks on the Strength and Ductility of Malleable Cast Iron After the Skin has been Removed, Enrique Touceda (13 pp., 3 figs. *pe*). This article discusses the question of the strength and ductility of malleable cast iron after the skin has been removed, and combats the idea that, after the skin has been removed, the remaining metal is of inferior quality, if not absolutely worthless. As regards the structural composition of good malleable iron, one must bear in mind that, if it has been properly annealed, its structure must consist of ferrite and free carbon, and with

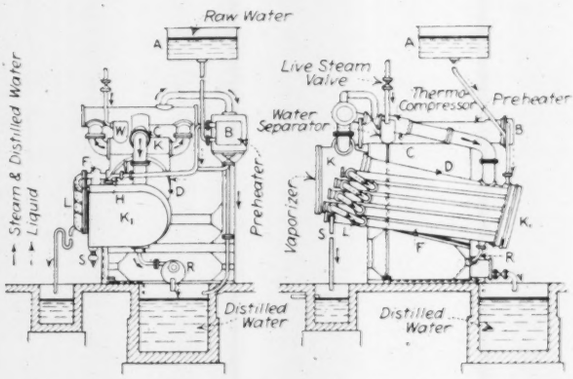


Fig. 6 Evaporation Apparatus for the Production of Distilled Water

the exception of the ferrite in the rim, the ferrite in the rest of the piece is contaminated more or less with free carbon, so that, with two exceptions, the structural compositions of wrought and malleable iron are in the main identical. One of these exceptions is that the ferrite of the malleable iron is higher in silicon than that of the wrought iron, but that affects neither the ductility nor the size of the crystals of the ferrite. The other exception results from the presence of free carbon in the ferrite of malleable iron, which may affect the strength of the iron and ductility of the material where it occurs in concentrated form, in patches. As regards the skin, it appears that if the annealing process has been arrested at the exact moment when the last trace of free or pearlitic cementite in the casting has been broken up into ferrite and free carbon, there will be around the edge of the casting a rim about $^1/_{32}$ in. deep of practically carbonless iron. The structure of the balance of the section is very uniform throughout. The author discusses at certain length the influence of the rim on the strength of the bar and its elongation, and while he admits that the rim can add greatly to the final strength of the bar, he questions the possibility of its affecting the elongation, at least affecting it favorably, and comes to the conclusion that any record of elongation on a malleable iron test bar expresses elongation of the metal *in the core only,* as the metal in the rim is capable of further stretching.

The author during the past few years has made numer-

ous physical tests on malleable cast iron, and he noticed that defects nearly always exist in the bars such as are usually made for tensile tests, due to the unsoundness caused by shrinkage or faulty contraction as the case may be. Many test bars are made with a reduced section either to enable the grips of the machine to hold the specimen better or to force the bar to break outside the grips. A bar cast in this manner is nearly always defective, due to the inability of the iron to set normally. In bars of uniform section throughout, defects are frequently found to exist at the central portion of the bar. In experiments to determine the difference in strength between skin and core, often as much as $^1/_{16}$ in. of the stock is removed in the finishing cut all around the bar which represents perhaps 30 per cent of the original area and sometimes even more. If the region around the center of the test bar is unsound, the data of such a test can give no information as to the relative strength of the metal in skin or core. In order to determine the relative strength of machined pieces and pieces with the skin on, dynamic tests were made with the following results:

AFTERNOON HEAT OF JUNE 3	
Unmachined wedges	Machined wedges
Average of 4 tests, 18.5 blows	Average of 4 tests, 13.2 blows
AFTERNOON HEAT OF JUNE 4	
Unmachined wedges	Machined wedges
Average of 4 tests, 29.75 blows	Average of 4 tests, 26.3 blows
MORNING HEAT OF JUNE 6	
Unmachined wedges	Machined wedges
Average of 4 tests, 19.75 blows	Average of 4 tests, 21.2 blows

The author discusses in further detail the question as to why he selected for the test purposes bars in the form of wedges, a shape which appears to give good results for this particular purpose.

Elimination of Waste Motion in Bench Molding, R. E. Kennedy and J. Pendleton (10 pp., 4 figs. *dp*). The article describes methods of elimination of waste motion in bench molding. In studying the conditions existing in an ordinary foundry, the writer has found a considerable amount of wasteful lost motion due to an inconvenient arrangement of the bench, and it was found best to have the benches made of the wall type, even though in a great majority of cases a portable bench over the sand pit is most economical, due to the reduced handling of sand and mould. On the bench shown in Fig. 7, the arrangement is such that the tools have to be placed in the proper places and the foreman or molder can see at a glance whether the tools are all in proper condition. Every tool can be seen at once, so that there is practically no loss of time in searching for it on the bench. The tool box is returned to the tool room each evening, when the condition of the tools may be inspected. Special tools are placed in the box issued to the molder assigned to a particular job where they are required, and the bench cannot then be littered with a mixture of tools, patterns, old cores, etc. The two brackets marked *AA* are to hold the cope when no patterns are to be drawn from it.

AMERICAN INSTITUTE OF MINING ENGINEERS

July 1914, New York City

Draining Kerr Lake, Robert Livermore
Nodulizing Blast-Furnace Flue Dust, Lawrence Addicks (abstracted)
Basic-Lined Converter Practice at the Old Dominion Plant, L. O. Howard

August 1914

Melting of Cathode Copper in the Electric Furnace, Dorsey A. Lyon and Robert M. Keeney
Tests of Rock Drills at North Star Mine, California
Rope Idlers in the Raven Shaft, George A. Packard
Electrical Fume Precipitation at Garfield, W. H. Howard
The Annealing of Cold-Rolled Copper, Earl S. Bardwell (abstracted)
Curves for the Sensible Heat Capacity of Furnace Gases, C. R. Kuzell and G. H. Wigton

Nodulizing Blast Furnace Flue Dust, Lawrence Addicks (July 1914, 4 pp. *ep*). The article describes a process used at the refinery of the United States Metal Refining Company, Chrome, N. J., where a large amount of unsmelted blast furnace flue dust has been accumulating and some scheme had to be devised for usefully taking care of this material. After a careful consideration of the problem, the process of nodulizing was decided upon. The kiln was approximately 2 ft. in diameter and 20 ft. long and was fired with fuel oil, the consumption being about 50 gal. of oil per ton of flue dust. Later, a larger kiln, 60 by 6 ft. was decided upon with a 6 in. brick lining. With the test kiln, there was a decided tendency to the formation of nose rings, and it was found that to avoid them a steady condition of flame was very necessary. Trouble was also experienced because of a formation and subsequent plastering of sand on the walls through overheating of the kiln. This could be obviated only by skill and care on the part of the attendant. As regards the comparison of nodulizing with blast roasting, it was found that the former was entirely independent of the necessity of having a properly balanced internal fuel supply.

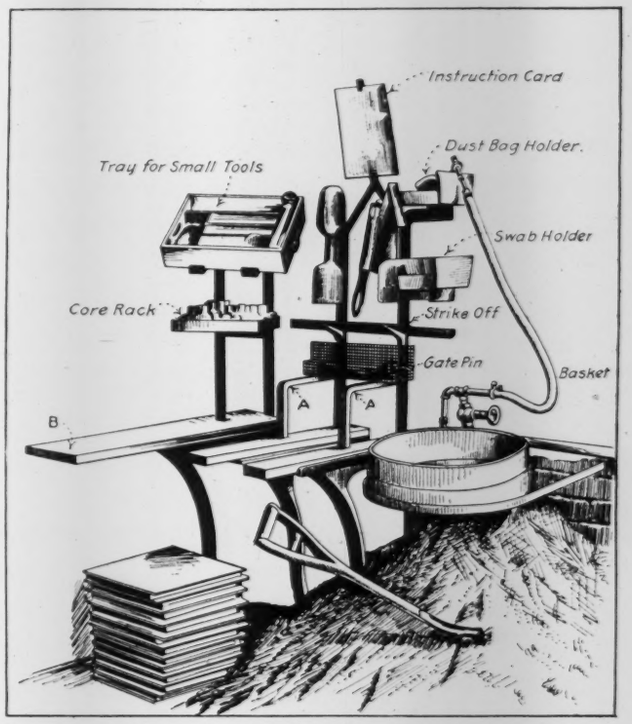


Fig. 7 Molding Bench

As far as the operating cost goes, the cost of fuel is the deciding element. A single operator can attend to the firing of several kilns, and the repairs should be small as

the machinery is simple, thoroughly standardized, and not exposed to the heat.

THE ANNEALING OF COLD-ROLLED COPPER, Earl S. Bardwell (20 pp., 20 figs. *eA*). The author discusses the annealing of cold-rolled copper with respect to the effect of annealing temperatures on physical properties and changes in the microstructure of refined copper due to cold-rolling and annealing. As regards the former, the test bars were selected with the contents of copper and silver together from 99.93 to 99.95 per cent and varying in oxygen contents between the limits of 0.036 and 0.070. The tensile strength of copper wire annealed at various temperatures is given in the article both in the form of tables and curves. It was figured out by multiplying the breaking weight in pounds by the reciprocate of the cross-section area in square inches. As the temperature of annealing increased, the tensile strength pretty uniformly went down from 63,000 to 65,000 lb. at a temperature of annealing of 60 deg. fahr. to about 35,000 lb. at 1000 to 1100 deg. fahr., and then began slowly to rise from 37,000 to 39,000 lb. for a temperature of 1800 deg. fahr. On the other hand, the percentage of elongation reached its maximum at about 1300 deg. fahr. The author compares his results with the results obtained by the French investigator, Capt. C. Grard, whose results differ materially in some respects from those obtained by the author, but this article goes further into detail with respect to the changes in the microstructure of refined copper due to cold-rolling and annealing. It is found that the temperature at which strained metal is annealed seems to exert considerable influence upon the formation of polysynthetic twin crystals as well as upon the size of the crystals in general. The increase in the size of the crystals is accompanied by a decrease in the per cent of elongation, which is of interest since a piece of annealed metal having a maximum per cent elongation is in the best physical condition for withstanding further mechanical treatment. As regards the trouble caused by over-heating copper in the annealing furnace, it appears that over-heating facilitates the development of polysynthetic twin crystals and results in a decrease of the per cent elongation. Sheets which have been overheated in this way give trouble by cracking at the edges. If the annealing temperature is very high, gases which are unable to escape when the metal is cast, tend to segregate at the granular boundaries. Overheating the copper previous to the breaking-down rolls, as a rule, results in blisters. When the annealing temperature becomes so high that the metal begins to soften, the gases contained in the metal tend to force the grains, thus causing cracks into which the oxygen in the atmosphere penetrates.

Bulletin, September 1914, New York City.

Curves for the Sensible-Heat Capacity of Furnace Gases, C. R. Kuzell and G. H. Wigton

The Surface Decarbonization of Tool Steel, J. V. Emmons (abstracted)

Coal-Dust Explosion Investigations, M. J. Taffanel

Rolled Steel Roll Shells, James C. H. Ferguson

Finishing Temperatures and Properties of Rails, George K. Burgess, J. J. Crowe, H. S. Rawdon, R. W. Waltenberg

Manganese Steel and the Allotropic Theory, Albert Sauveur

THE SURFACE DECARBONIZATION OF TOOL STEEL, J. V. Emmons (15 pp., 13 figs., *teA*). The article discusses surface decarbonization of tool steel. The phenomenon itself has been observed before, but the origin and effects of it have been but little studied. In order to investigate the reaction occurring in the surface decarbonization and to determine the rate at which it proceeds at various temperatures, pieces from a bar were annealed in a strong current of pure dry carbon dioxide at various temperatures, after which a microscopic examination was made of the cross-section and the depth of decarbonization measured by means of a micrometer eye piece. For greater ease and accuracy, it was measured only from the surface to the point of supersaturation or to the point where free cementite first made its appearance. In all these experiments, decarbonization has been effected by oxygen in the form of a gas. In order to determine if it is necessary for the oxygen to be in the form of a gas to combine with the carbon in the steel a crucible of lead was saturated with lead oxide by the addition of litharge. The test piece was annealed in it for three hours at 1500 deg. fahr., after which a microscopic examination revealed decarbonization to a depth of 0.024 in., which shows that easily reducible oxides when dissolved in a metal bath may also effect the elimination of carbon. The experiments have on the whole shown that carbon is removed from steel by a process of oxidation which may be effected either by gases or liquids: that among bases, the principal active agents are air, carbon dioxide and water, while as to the liquids, any good oxidizing agent dissolved in a liquid bath may be the active agent. During the annealing, carbon dioxide necessary for the elimination of carbon may be formed through the reduction of iron oxide by carbon monoxide, but no case has been observed where carbon was eliminated while the steel was heated below its critical point, which proves that carbon must be dissolved in the iron before decarbonization can take place. The rate of decarbonization under uniform conditions is constant without regard to the depth to which it has proceeded. This would tend to indicate that the carbon is transferred from the interior to the surface by diffusion toward the solid solution.

The practical importance of decarbonization of tool steel lies in the difficulty of machining what is known as "bark" or the decarbonized surface, which must be removed before the steel can be used for cutting tools, wearing surfaces, etc. The depth of the bark may vary greatly, owing to oxidizing conditions during the hammering, rolling and annealing of the rough material. The common method of determining the thickness of the bark is by examining the hardened fracture by means of the naked eye or under a magnifying glass. The bark shown is coarser grained than the high carbon interior. The author has made a number of experiments to determine the reliability of this method, the data of which will be found in the Table 1, p. 0199. From it, it appears that with the increase of temperature there is an increase in the amount of bark, due obviously to the fact that an increased amount of cementite is held in solution by quenching from the higher temperatures. The method of inspection by the naked eye or under a magnifying glass is therefore reliable only when the hardening heats are carefully regulated and the results frequently checked by microscopic examination. The most reliable method of inspection is by microscopic examination of an annealed specimen in which case the measurement of the depth of decarbonization may be made with a micrometer eyepiece.

In the machining of tool steel, the bark presents serious difficulties which increase still further when the machining is done in such a manner that only a part of the layer of coarse pearlite is removed. In this case the surface of the work will be rough and the point of the tool worn out with great rapidity. The cause of the appearance of a layer of coarse crystals is the difference between the critical points of eutectoid and hypereutectoid steel, the eutectoid steel being at the correct temperature for annealing, while the hypereutectoid steel is far enough above its critical point to allow the crystallized grains to grow to a considerable size. The cause of the hard wear on the cutting tool when encountering bark formation is due to the way the tool cuts, viz., the fact that when removing a chip from a piece of metal, it splits it off by an action similar to a wedge so that the hardest work of the tool occurs not at the extreme point, but a short distance back from the point where the pressure of the chipping is greatest. There is therefore always a crack running ahead of the tool as it is forced through the material which is being cut, but when the tool is cutting in coarse pearlite, this crack will follow the lines of least resistance which in this case are the boundary lines of the grains and through the grain in the direction of the laminations. The larger the size of crystalline grains, the more irregular will be the crack and the rougher the resulting surface. Now the rough surface left by the crack running ahead of the tool increases the amount of work and friction on the extreme cutting edge, the point of the tool being obliged to rub over the protruding grains of pearlite and to tear out some of them entirely. This is intensified by the great abrasive quality of the cementite when held by alternate plates of ferrite. The case becomes even worse when the bark consists of a band of coarse hypereutectoid steel below the band of coarse pearlite, in which case the coarse grains of pearlite are bound by a cementite underwork which seems to add greatly to the difficulty of machining. That the bark has to be removed there can be scarcely any doubt, since when a piece of steel is hardened the surface is hardened only in proportion to the carbon it contains. Since, further, in the great majority of cases where tool steel is used, it is the edge that takes up the most severe work, the presence of the bark would rapidly produce blunt edges in tools, undersized in reamers and twist drills, or over sized in dies.

TABLE 1 DEPTH OF BARK AS A FUNCTION OF TEMPERATURE OF HARDENING

Temperature of Hardening, deg. fahr.	Depth of bark, inches
1370	0.015
1380	0.018
1390	0.018
1415	0.018
1435	0.021
1460	0.020
1490	0.024
1530	0.027

AMERICAN SOCIETY OF CIVIL ENGINEERS

Proceedings, vol. 40, no. 6, August 1914, New York City.

External Corrosion of Cast Iron Pipe, Marshall R. Pugh (abstracted)

The Design and Construction of Four Reinforced Concrete Viaducts at Fort Worth, Texas, S. W. Bowen

The Clarification of Sewage by Fine Screens, Kenneth Allen

External Corrosion of Cast Iron Pipe, Marshall R. Pugh (50 pp., 21 figs. *gp*). The discussion of conditions where special protection of cast iron pipes against external corrosion is needed and suggestions of preventive methods adopted to different cases, forms the chief part of this article. The author takes up in considerable detail cases where cast-iron pipe proves extremely durable as well as where it deteriorated very rapidly. He mentions the acid and electrolytic theories and shows that among the conditions contributing to corrosion, the following may be mentioned.

The rate of corrosion has been found to increase in proportion to the increase of free carbonic acid. Cast iron subjected to slow action of dilute acids, as for example acid water from mines, retains unchanged the external shape of the casting, but the composition of the metal is altered, iron being removed in solution. Rain water, particularly in thunderstorms, contains nitric acid or nitrates which may also be present in polluted waters; potassium nitrate or potassium sulphate have been found to produce strong corrosion; magnesium and ammonium chlorides (the form found in sea water) corrode iron even in the absence of air. Oxygen plays a very important part in corrosion. The rate of motion of water also has a bearing on the rapidity of corrosion, as under certain circumstances it brings a constantly renewed supply of air to the rusting metal. The action of living matter has likewise to be taken into consideration for, although the direct action of any organism is doubtful, it is possible that certain living organisms secrete acids which lead to corrosion. This applies both to the animal kingdom and humic acids. In certain places, for example in Southern Illinois, the soil shows a marked acid reaction, and when it does, it produces a material intensification of corrosion of steel structures. When this acid content exists only to a certain depth, steel buried at a greater depth does not seem to exhibit any unusual tendency to corrosion. The author discusses also the conditions of inhibiting corrosion, such as the effect of concrete, siliceous scale on cast-pieces, the presence of small quantities of chromium, nickel and copper in the iron, the presence of phosphorus and the coating of iron with zinc or tin. He discusses a number of cases of deterioration of cast-iron pipe. Among the recipes to prevent rusting of iron, he quotes one given in the year 1790, which is as follows:

"Fry a middling eel in an iron pan, and when brown and thoroughly fryed, express its oil and put into a phial, to settle and become clear in the sun. Iron annointed with this oil, will never rust, although it lay in a damp place."

The more modern method which the author recommends is resorting to the improvement of the skin resistance of the metal. The use of lime in the trenches so as to encase the pipe in an inhibiting alkali is also recommended. Leaving the pipe in an open trench might also be a help as the alternate wetting and drying would probably be preferable to a constant exposure to moist air, salt and carbonic acid in the swamp soil. At Atlantic City, the cast-iron water mains across the salt marsh have been raised above the surface of the middle of the marsh so that they are entirely in the air. In certain cases it is advisable to galvanize cast iron instead of giving it the ordinary bituminous coating. This method has also been used in some instances for the protection of gratings, covers and similar castings. The writer is not aware of its having been applied to cast-iron pipe.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Journal, vol. 26, no. 3, August 1914, Washington, D. C.

The American Society of Naval Engineers, Its Origin, Scope and Purpose, Rear Admiral John R. Edwards
The Engineering Experiment Station, H. G. Bowen (abstracted)
Optical Glass, F. J. Cleary
Method of Mending Crack in Cylinder Flange, Capt. F. W. Bartlett
The Dynamical Equivalent of Heat, Rear Admiral John Lowe
Notes on Evaporating Plants, H. C. Dinger
Corrosion of Common Metals and Methods of Prevention, S. J. Zeigler
Notes on Aeroplane Stabilization, Wm. L. Cathcart

THE ENGINEERING EXPERIMENT STATION, H. G. Bowen (15 pp., 16 figs., *g*). The article presents briefly the results obtained at the Engineering Experiment Station of the United States Navy at Annapolis. This station appears to have definitely proved its value to the United States Navy, as, e.g., it has in some cases materially reduced the price paid for navy supplies. It is conclusively shown that rubber sheet packing is worthless for high pressures and that, for the present, metallic ring packings have no substitute. Tests with respect to gage glasses have shown that the glass of tubular or reflex gages corrodes in high-pressure steam under the usual surface conditions, and if this action continues long enough, the glass will dissolve and finally fail under pressure. The only certain and efficient method of protecting the gage is by covering the pressure side of the glass with a thin sheet of mica which keeps the glass transparent and unattacked as long as the mica covering is intact. Further, it has been found that superheated steam corrodes and does not erode valve fittings, and that monel metal resists this corrosive action better than class *A* or *B* steel.

With respect to lubricants, it has been found that when sulphuric acid is mixed with oil while the latter is being refined, the oil may form a sulphonated product which is not wholly eliminated and may, under sufficient agitation, pressure and temperature, break down into acid and waxy sludges. A specially constructed machine has been provided for testing forced lubrications under service condition and observing their action when mixed with salt water (see *The Journal*, July 1914, p. 152).

The subject of corrosion of packing and boiler plates has been investigated and among other things, the strength of a solution of sodium carbonate, which would render all boiler materials non-corrosive, has been established and a compound has been issued to the service having the following composition:

Calcined soda ash (96 per cent Na_2CO_3)	64 to 69 per cent
Tri-sodium phosphate (96 per cent Na_3PO_4)	15 to 20.5 per cent
Glucose	1.5 per cent
Tannic acid (contained in cutch digested with caustic soda)	9.0 to 10.0 per cent

The tannic acid is introduced in order to hold the precipitates in suspension and to prevent adhesion of the scale-forming salts to the heating surfaces while the glucose tends to prevent adhesion of any sulphate scales.

The testing of feedwater heaters had quite a large share of attention in the Experiment Station, and reliable data on the transmission of heat in modern feedwater heaters have been developed. Among others there were made a series of tests to determine the rate of heat transmission in B.t.u. per sq. ft. of heating surface per hr. per deg. fahr. temperature difference between the steam and water at water velocities from 35 to 171 ft. per min. and with various shell pressures. Another series of tests was undertaken to indicate the performances of an apparatus as a multipass heater. Among other apparatus tested were boiler feed pumps, forced draft blowers, safety valves and feed meters. One of the valuable results of the work of the Experiment Station is said to be the elimination of material which on short stereotyped tests is satisfactory, but fails in long duration competition, as well as the elimination of undesirable or freak designs.

CANADIAN SOCIETY OF CIVIL ENGINEERS

Transactions, vol. 27, part 2, October to December 1913, Montreal.

Elevator Construction, J. Spelman (abstracted)
The Toronto Water Filtration Plant, F. F. Longley
Some Disregarded Stresses on Joints and Ends of Steel in Reinforced Concrete Construction, H. A. Icke (abstracted)

ELEVATOR CONSTRUCTION, J. Spelman (10 pp., 23 figs., *d*). The article gives a brief historical sketch of early elevator construction and describes a number of units, mainly in Canada. Among other things, the author states that in the elevator at Victoria Harbor, Port McNicoll, a concrete stack was built which had a good many cracks in it, the reason of which was that there was not sufficient concrete in the stack. Since then, another stack has been erected in which there are no cracks and the theory upon which it was built was to put in enough steel to take the tension if the concrete cracks and then enough concrete to take the tension anyway, so that the tension on the combined section of the concrete and the steel should be large enough to prevent the concrete from cracking, the walls being about twice as thick as those made by the ordinary stack builder.

SOME DISREGARDED STRESSES ON JOINTS AND ENDS OF STEEL IN REINFORCED CONCRETE CONSTRUCTION, H. A. Icke (5 pp., 5 figs., *t*). The author considers the disrupting forces which may occur as the result of the development of different degrees of strain in contiguous parts of the steel, or steel and concrete, especially in lap joints, and while no claim is made to the establishment of a theoretical method of determination of the precise effect of these disrupting forces, he recommends the following practical rules for their prevention:

(1) Bars forming lap joint and sustaining either tensile or compression stress should each be curved away from the other for a little less than half the lap, so that the angle of deflection of the curve and approximately the divergency between the two bars, at any distance from the point of springing of either curve, may be proportional to the difference of the stresses carried by the bars at that distance from the springing.

(2) Bars should not end pointing in the same direction as the stress (either positive or negative) carried by the concrete or contiguous bars, but approximately at right angles thereto.

(3) Bars cannot pick up stress in the same direction as, but differing in sign from, the stress carried by the concrete in which they are imbedded.

CORPS OF ENGINEERS, UNITED STATES ARMY

Professional Memoirs, vol. 6, no. 29, September-October, 1914, Washington Barracks, D. C.

Development of Explosive for Our Demolition Equipment, Major W. G. Caples

The U. S. Seagoing Suction Dredge "New Orleans," Major E. H. Schulz (abstracted)

Winter Work in the Construction and Repair of Dams and Shore Protections in the United States Improvement of the Upper Mississippi River, C. W. Durham

THE U. S. SEAGOING SUCTION DREDGE "NEW ORLEANS," Major E. H. Schulz (12 pp., 4 figs., *d*). The article describes a suction hopper type of dredge with twin screws and twin rudders, built in this country. The peculiar feature of this dredge is the suction-head. This is of the Frühling type, and is at the end of the drag-arm, which is hinged and suspended from the stern of the vessel.

The dredge arm is a girder, and measures 68 ft. 6 in. between trunnion centers and dredge-head axis. It is built up of steel plates and angles attached at each end to steel castings of extra good quality. The two 26-in. steel suction pipes are built into and form part of the dredge-arm. The steel castings (trunnions) at the forward end of the arm work in steel trunnion bearings forming part of the hull in the well. To the castings at the after end of the arm are attached, first, the suction-head trunnions, and then the suction-head. Both the suction-head and suction-head trunnions were made of vanadium cast-steel. The castings at the ends of the dredge-arm are hollow and form part of the suction pipe.

The original suction-head is made of segments of three widths, and can be made 10 ft., 16 ft. 8 in., or 20 ft. wide. The pressure water (200 lb. per sq. in.) can be used as jets on the cutting edge to loosen hard material, or as mixing water inside the head when the mud is thick enough to choke up the suction to the pumps. The opening in the suction-head is controlled by portable baffle-plates.

The suction end of the arm is attached to the special hoisting winch at the stern of the dredge, by two extra pliable plough-steel cables $1\frac{1}{4}$ in. in diameter. These cables are played in and out, depending on the depth and character of material. At about the center of the dredge arm are two oak guides with steel wearing plates that work on steel rubbing plates on the sides of the well. The dredge-arm, including the suction-head, weighs about 60 tons.

The method of socket connection first used was as follows: The ends of the wire (Fig. 8A) were passed through the socket, served inside the socket with wire, the end unlaid, the heart taken out, the ends of wire bent over into the socket, and the spike driven into the heart. The ends were then brought together and pulled into the sockets with a tackle. After the end was pulled in, the socket was poured full of Magnolia white metal, and allowed to cool.

An accident occurred, however, which caused a test to be made at Tulane University, in which it was found that socket connections made exactly similar to those which broke on the dredge began breaking at loads of 44,000 and 38,200 lb., respectively, and the maximum loads carried were 53,340 and 58,090 lb.

The design of the socket has therefore been changed, and the method of connecting the cables now adopted is as follows: The cable is spliced around a thimble (Fig. 8B), making a loop, which takes the place of the eye of the socket. No data as to the strength of this construction are given.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Proceedings, vol. 30, no. 4, May 1914. Pittsburg.

Measurement of the Velocity of Flowing Water, Lewis F. Moody

Pitot Tube Formulas—Facts and Fallacies, B. F. Groat (abstracted)

PITOT TUBE FORMULAE, B. F. Groat (59 pp., 12 figs., *dtp*). The article discusses the application of the pitot tube formulae and possible fallacies in this connection. The author calls attention to the great difference of opinion as to whether the head raised in a pitot tube is equal to the velocity head of the impinging water or to twice that velocity head, and shows from the Bernoulli formula that the head cannot be twice the velocity head of the impinging water. He shows further that it is incorrect to claim that the effects of eddies and friction would tend to cut down the head so as to vitiate either of the resulting formulae applied in the case of the pitot tube. In the paper itself the author proves that the formula $h = \frac{v^2}{2g}$ applies to the pitot tube while the formula $h = \frac{v^2}{g}$ applies to the case of a jet impinging perpendicularly upon a plane surface. He

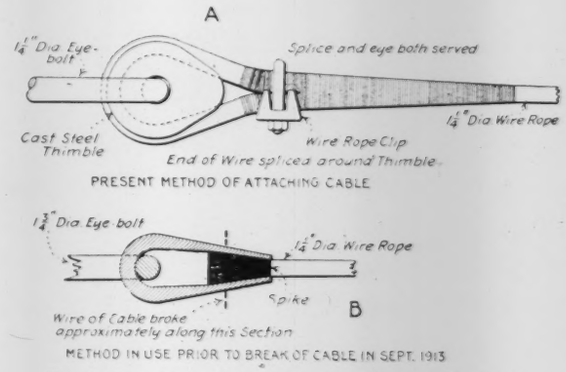


FIG. 8 TWO METHODS OF ATTACHING CABLE IN DREDGES

shows also that in both of these cases, the actual maximum pressure head developed in the water is the same and is equal to $\frac{v^2}{2g}$, but the total pressure on the plane surface, if divided by the numerical value of the area of the jet, would be equivalent to an average pressure head representd by $\frac{v^2}{g}$.

An interesting part of the paper is that reporting the results of experiments by the writer, made while conducting an elaborate series of turbine tests, as well as a method of determining the coefficient of the pitot tube by a comparison of its records with the corrected records of two different types of current meter when these records are derived from the variable velocities of a tail race.

The author has found as being unqualifiably proved by experimental facts that the intensity of pressure of a jet of water upon the face of a plate is always and everywhere upon the plate less than $\frac{wv^2}{g}$, where w is the weight of a cubic unit of water, and that experiments on taking manometer pressures through holes in the plate, show that the pressure upon the surface of the plate is nowhere greater than $\frac{wv^2}{2g}$, equaling this value at the center and diminish-

ing radially therefrom in all directions. The author then proceeds to an experimental determination of the distribution of pressure from a plane surface upon which a jet of water impinges. He starts from data obtained by William Monroe White, in America, and J. S. Beresford, in India, who found that the pressure falls to a negligible value at the distance from the axis of the jet equal to the diameter of the jet and that the portion of the area of the plate which sustains any appreciable pressure is about four times the sectional area of the jet.

From the experiments of Beresford, it appears that in no case did the intensity of pressure reach that due to a column of water of a height equal to the head of water in the barrel; or in other words, to that of a head due to the velocity. In some cases it approached this limit to within $^1/_{16}$ of an inch, so that had interfering causes been entirely removed, the surface of the water in the two glass tubes would have been on the same level for actual positions of the plate.

The author presents a simple mathematical proof of the pitot tube formula, which is not, however, convenient for abstracting. The conclusion to which he comes is that the change in pressure depends in no measure upon the manner in which the velocity changes from point to point, but only upon the initial and final values of the velocity, and that since the total reaction depends upon the initial and final values of the velocity and not upon the intermediate velocity gradients, the pressure head over a finite area at some point within the pitot tube is practically uniform and equal to $\frac{v^2}{2g}$.

The paper discusses to a certain extent questions of the effect of form of static opening and the reaction of a jet with respect to the static opening. The author agrees with the statements made by Mr. W. C. Rowse in his paper on Pitot Tubes for Gas Measurement in the Journal of the Am. Soc. M. E., September 1913. He discusses further the problem of the standing wave as an illustration of the operation of hydrodynamic forces as well as what he calls "natural pitot tubes."

One of the problems which the author set for himself was to determine the correctness of the indications of the pitot tube when handling very large amounts of water, e.g., such as would come from a 6000-h.p. turbine, when the observations are made in irregular currents of variable velocity. To do this, the author decided to make tests with two different types of current meter and should the meter tests not agree, to check the meters by means of a pitot tube. The meters used were a new Haskell meter of the screw type and a new large sized Price meter of the cup type, carefully rated from a boat and found to be quite reliable in the ratings when conditions were favorable. When, however, conditions were not favorable, the ratings of the two meters were found to vary quite materially; it was later determined that if the boat was rocked during the ratings, the meters would change their rates of rotation in such a way that the cup meter was always accelerated considerably while the screw meter was always retarded slightly. When the boat was rocked in about the same manner, in two ratings, one upon the screw meter and the other upon the cup meter, the deviations of the screw meter were about 1-7 those of the cup meter on the side of deficiency, the deviations of the cup meter being on the side of excess, but when the two meters were operated simultaneously in a tail race, taking the readings of equal weight, in two different comparisons, for the same meter points, the ratio of the sum of the velocities by one meter to the sum by the other meter was an almost perfect constant for the same discharge; i.e., the meters had perfectly definite ratings in the races, but these ratings were not the same as those determined from the readings in still water. Nevertheless, there was a means of estimating the true velocity of a perturbed current by means of simultaneous observation with a cup meter and a screw meter which gave a basis for determining the coefficient of the pitot tube.

The article describes and illustrates the type of pitot tube used by the author in his experiments. It has an interesting and apparently convenient supporting arrangement. In the turbine tests the dynamic orifice of the pitot tube was connected to the interior pipe while the static orifice was connected to the space between the outer casing (1-in. gas pipe) and the interior pipe (¼-in. gas pipe). Table 2 gives a summary of the results of the comparisons of pitot tube ratings with meter ratings, representing the result of about 4000 individual readings of the head indicated by the pitot tube. It shows that the ratio of the aggregate pitot tube velocity to the aggregate Haskell velocity, by the table, is 1.004, so that on an average, the velocity of the pitot tube is greater than that of the meter. If, however, a ratio of aggregates is derived which is not affected by the variations due to differences in depth, revised figures such as are shown in Table 6 are obtained, the coefficient of the pitot tube in the last column being the ratio of the true velocity to the pitot tube velocity.

TABLE 2 SUMMARY OF PITOT TUBE AND HASKELL METER COMPARISONS FOR 99 VELOCITIES TAKEN IN DEPTHS 2, 3, 5, 6, 7 IN THE TAIL RACES

(About 4000 individual readings of the head indicated by the Pitot tube were made for the purpose of determining the figures in this table.)

Depth	No. of Expt's	Pitot	Meter	Ratio P ÷ M
2	22	76.55	72.59	1.055
3	22	82.03	81.98	1.001
5	22	86.11	86.37	0.998
6	14	59.11	60.17	0.982
7	19	80.73	82.06	0.984
Totals.	99	384.53	383.17	1.004

TABLE 3 CORRECTED PITOT TUBE AND HASKELL METER COMPARISONS

(Compiled from Tables 2 and 5)

Depth	True Velocity Table No. 2	Velocity by Haskell Table No. 2	Ratio of Vel. by P to Vel. by H Table No. 5	Computed Velocity by Pitot	Coefficient of Pitot Tube
2	3.98	3.90	1.055	4.11	0.968
3	4.48	4.44	1.001	4.44	1.010
5	4.92	4.89	0.998	4.88	1.009
6	5.57	5.55	0.982	5.45	1.021
7	6.17	6.15	0.984	6.05	1.020
	25.12	24.93		24.93	1.008

Mean coefficient of Pitot tube in tail races = 25.12 ÷ 24.93 = 1.008.

In closing, the author describes a boat rigging which may be conveniently employed on large rapid streams of considerable depth where it is intended to determine the discharge by means of a pitot tube or current meter. In an appendix the author explains the principles of a chemical method of measuring the discharge of water by means of introducing into the water upstream a certain reagent and bringing it, in the water, downstream. He explains the precautions which have to be taken and the general method of carrying out the analysis and estimation. A bibliography of the measurements of air, gas and water flow by means of a pitot tube is given.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Transactions, vol. 30, part 4, August 1914, Newcastle-upon-Tyne.

HIGH-SPEED BEARINGS, Gerald Stoney (14 pp., 13 figs. and 3 plates, *dg*). The article gives a brief historical sketch of the theory of friction and lubrication as applied to high-speed bearings as well as the marine situation in this field of engineering. Among other things, the author gives fairly complete data of the experiments on high-speed bearings, made by O. Lasche, which are of particular interest because the number of *Traction and Transmission* (vol. 6, numeral 22, 1903) in which they were published, is now out of print. His tests show that so far as friction is concerned, it is not well to use a large shaft and a long bearing, which, however, have to be used for high speeds and heavy loads in order to avoid vibration, critical speeds and fractures due to vibrations. If the pressure is not too high nor the oil too thin, a bearing may run all right so long as there is no vibration, but if vibration occurs, the oil film may be driven out and seizing take place. Besides, in all high-speed bearings, artificial means have to be used to carry off the heat, the radiation from the bearings not being sufficient. This is important, since from Lasche's experiments it was found that the friction is practically inversely proportional to the temperature measured from freezing point, but after a certain temperature, it directly increases and seizing takes place, due to the loss of viscosity. Water jacketing the bearings has not been found as satisfactory as the plan of supplying sufficient oil to carry off the heat and oil coolers are preferable (to cool the oil) as well as oil circulation around the outside of the bearings. The heat to be removed is not only that caused by friction, but also that caused by conduction from the steam. The heat which has to be carried off by the oil may be expressed as

$$\text{B.t.u.} = Kdlv$$

where d is the diameter of the bearing in inches, l the length of the bearing in inches, and v the surface velocity in feet per second, the constant K varying inversely as the temperature above freezing point.

In marine practice, the formula B.t.u. $= dlv^{1.38}$ is used and gives slightly greater results for the usual speeds in marine work and an oil temperature of about 100 deg. fahr. Thrust bearings in land turbines which are perfectly balanced, are working with very low pressures, never exceeding 20 lb. per sq. in. and even in marine turbines, 50 lb. per sq. in. is never exceeded. There are no tests available as to the friction of such bearings, but it is probably fairly high, as perfect lubrication is difficult to obtain and as, in addition to the area of the main bearings, the area of the top and bottom halves of the collar have to be added in estimating the quantity of oil required and the surface of the oil cooler. Owing to the low pressures employed, such bearings have usually a high coefficient of friction as the lubrication is rarely perfect on account of the general operation being different from that of journal bearings and no wedging action taking place and admitting oil. The author proceeds to describe the investigation of Osborne Reynolds and Michell which led the latter to devise his well-known thrust bearing with segmental blocks pivoted at the theoretical center of pressure.

In the discussion which follows, Mr. Newbigin calls attention to the effect of the slipper shaped blocks in the pivoted thrust bearing and stated that the friction increases rapidly when the length in the direction of rubbing is more than the radial dimension of the block. Better results were obtained when the blocks were pivoted at or near the theoretical center of pressure in the oil film than when pivoted in the center of their area. The latter method of pivoting is not mechanically simpler since bearings with the blocks pivoted behind their center of area for both directions of rotation have been made for the last three or four years without mechanical complications.

With respect to the effect of pivoting the blocks incorrectly, the following results of tests were given:

TESTS ON MICHELL THRUST BEARINGS MADE AT MESSRS. BELLIS & MORCOM'S WORKS, BIRMINGHAM, JUNE 8 AND 9, 1910

There were three blocks in the bearing, each having a surface of 1 sq. in. The cross dimensions of the blocks were equal.

The temperature was taken by means of a thermometer placed in a hole drilled in one of the blocks.

Speed 1750 r.p.m., or 28.67 ft. per second
Absolute viscosity of the oil at 126 deg. fahr., 4.6
Pressure on the blocks, 500 lb. per sq. in.

Position of Pivoting Point	Temperature of Bearing. Deg. Fahr.
1/16 in. in front of center	135
Central	132
1/16 in. behind center	126
1/8 in. behind center	124

Increase in friction for blocks centrally pivoted, 15 per cent

TESTS MADE BY MR. MICHELL IN MELBOURNE, SEPT. 2 TO 15, 1913

Diameter of Thrust Collar, 6 in.
Number of Blocks, 2
Area of bearing surface of each block, 4.5 sq. in.
Total load on blocks, 5000 lb.
Mean intensity of pressure, 555 lb. per sq. in.
Pivot 1/8 in. behind center of bearing surface with clockwise rotation
Pivot 1/8 in. in front of center of bearing surface with counter-clockwise rotation

TESTS MADE BY MR. NEWBIGIN

Mean radius of action, 0.16 ft.
Oil-Mineral, C.G.S., viscosity 0.1 at 60 deg. fahr.
Bearing air-cooled, radiating surface, about 2 sq. ft.
Bearing driven by small D. C. motor at an average speed of 1356 r.p.m.
B.h.p. required to drive the bearing under load, 0.372
Equivalent coefficient of friction, 0.0018

Duration of Test	Temperature of oil in bearing above that of the atmosphere at end of test.
Bearing running forwards—	
10 runs of 9 hours each	Average 85 deg. fahr.
Bearing running backwards—	
1 run of 8 hours	100 deg. fahr.

The blocks were weighed before and after a fortnight's run, and the loss was too small to be detected, being less than 2 grains.

Increase in friction for blocks running backwards, 16½ per cent.

Assuming the viscosity of the oil at working temperature to be 0.025 absolute, the coefficient of friction by Michell's formula would be 0.001025, as against 0.0018 by experiment.

Mr. Cook had the opportunity of conducting some experiments with pivoted segmental blocks for thrust bearings, and found the resistance of such thrust blocks and the ease with which they sustained high pressures to be very great.

The theory of lubricating films developed by Prof. Osborne Reynolds was not perfect in the estimation of the theory as it neglected the effects of temperature and capillary action, which latter might be considerable for thin films.

The following information on the design of oil coolers was presented during the discussion by M. G. S. Swallow and E. E. Williams.

The ordinary oil cooler was made like a condenser with the water circulating outside and the oil inside the tubes, the velocity of the oil through the tubes being about 2 ft. per second. Such a cooler with ordinary ⅝-in. condenser tubes and with cooling water at 65 to 60 deg. fahr., would cool oil from 115 to 100 deg. fahr., at the rate of about 2 cu. ft. of oil per sq. ft. of cooling surface. With smaller tubes ½ in. outside diameter about 3½ cu. ft. could be cooled, or about 4½ cu. ft. from 140 to 125 deg. fahr., but the pressure drop over the cooler was considerably increased. In some cases retarders had been used in the tubes or the tubes flattened at intervals like a Royles tube so as to increase the cooling effect by mixing the oil, but such devices increased the pressure drop very much, and were, in his opinion, of doubtful value.

The amount of cooling water might be about one-third of the volume of the oil, giving a rise of temperature in the cooling water about equal to the drop of temperature in the oil. A form of oil cooler which had been used very successfully on the Continent was one like an ordinary condenser with the water inside the tubes and the oil outside. By suitable baffles the oil was caused to pass several times at right angles to the tubes, and in passing through the tortuous spaces between them the oil became very thoroughly mixed up, and so the cooling was very complete. In such coolers it was stated that as much as 10 cu. ft. of oil could be cooled per sq. ft. cooling surface. The great advantage of such a cooler was not so much that it enabled a smaller cooler to be used, but that with a cooler of the same size as at present a better cooling effect could be obtained and the oil maintained at the lower temperature at which it retained its lubrication quality for a longer period.

A fair figure to take for fixing up the surface of an oil cooler for such conditions, i.e., 70 lb. pressure per sq. in. at a velocity of 30 ft. per second and a rise of temperature of 20 deg. fahr., was 200 lb. of oil per sq. ft. of cooling surface. The class of oil used on these examples was of a good standard as would be seen from the following comparison:

Standard	Oil Used
Flash point, 400 to 410 deg. fahr.	406 deg. fahr.
Specific gravity, 0.875 to 0.880	0.8755
Viscosity at 180 deg., 73/77 sec.	....
Viscosity at 140 deg.	155 sec.
Viscosity at 120 deg., 210/225 sec.	228 sec.
Viscosity at 100 deg.	395 sec.
Viscosity at 80 deg.	670 sec.
Viscosity at 70 deg., 930/960	.....

If a curve be plotted for comparison it would be seen that the oil used was up to the standard for flash point, specific gravity and viscosity. This oil was tested for viscosity after it had been subject to changes of temperature and it was observed that the oil did not quite reach the standard, as the flash point became 430 deg. fahr. sp. gr. 0.8790.

Viscosity 104 deg. at 400 sec.
112 deg. at 318 sec.
123 deg. at 232 sec.

A sample of the oil was submitted to a temperature of 150 deg. fahr. and it was found to have lost 54 per cent in weight, but no carbonization was observed at this temperature and practically no change of color. A further test was made and carbon was seen to form at 160 deg. fahr. Experience had been gained with bearings running at 160 deg. fahr. and it would appear from the state of the bearings after examination that the oil showed a tendency to carbonize at this temperature, which proved that a temperature of 150 deg. fahr. should not be exceeded.

SOUTH AFRICAN INSTITUTION OF ENGINEERS

Journal, vol. 12, no. 11, June 1914, Johannesburg.

THE PRINCIPLE OF SIMILARITY AND ITS APPLICATION IN MACHINE DESIGN (16 pp., 9 fig. *t*). The author proposes to show the adaptation of the principle of similarity to machine design. He claims that while exact similarity in machine design cannot be advocated in many cases, designers would be much less in error and would realize higher commercial economy by similarity entirely rather than varying proportions from little machines to large machines in the unscientific manner which he believes is so obvious in their design. The principle of similarity may be roughly expressed by saying that theoretical designs of all the machines of a series of engines of graduating power can be similar if similar conditions of working are assumed for all. The author proceeds to show what are the similar conditions of use, and how similarity applies to the case of roller-bearing, what the relation is between similarity and centrifugal whirling, and what fluctuation of velocity is permissible by fly-wheels of similar form in similar engines, as well as what are the fractional variations of speed allowed by similar governors in similar engines. He considers further the question of power and weight of similar engines working under similar conditions, that is constant linear speed and constant head of pressure. From this he passes to a brief discussion of similarity in automobile engines and steam turbines as well as to the relation of linear speed to economy of material, and the effect of reduced linear speeds, occurring in small engines on similarity of fly-wheels. The author uses mathematical methods sparingly and presents a clear account of this rather imperfectly known subject.

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

The war in Europe appears to have less influence on the files of papers at the Library of the Engineering Societies than was feared would be the case a month ago. Only a few German papers of minor influence have entirely suspended publication, and, of course, all the Belgian papers. The rest are appearing, though usually in a reduced size. The delivery appears also to have attained a considerable amount of regularity, so that there is now absolutely no doubt of the ability to maintain the Engineering Survey at the usual level of interest.

The greater engineering societies throughout Europe continue their activities. The German and Austrian Societies, in addition to purely engineering work, have gone into work of political and military nature. Thus, the Verein deutscher Ingenieure is recruiting engineers for the army, while the German Society of Steel Metallurgy is publishing and sending out with its official organ, reprints of telegrams from the seat of war, in German and English, purporting to present the true state of affairs from the German side.

THIS MONTH'S ARTICLES

The difficulties of manufacturing double acting two stroke cycle engines are presented in an abstract of an article by Hoffman in the section Internal Combustion Engineering. In the next section are indicated some data concerning the use of high speed tool steel and testing compressed air twist drills in German shipyards.

The article of Kaemmerer on auxiliary machinery aboard merchant ships, only part of which is abstracted here, covers several subjects of interest, such as the description of a new winch, evaporator, ball bearing, roller bearing, and a governor which is claimed to eliminate racing of the engine. In the same section will be found an abstract of an article by Loewe on the calculation of worm gear drives for the rear axles of power wagons. While this article does not present anything particularly new, it is given here because of the comparative scarcity of data on worm gear driving.

The article on steam and gas fired bakers' ovens by Pradel covers a somewhat neglected section of engineering to which the recent Gas Exhibition in Munich has given a considerable impetus in Germany.

The section on Steam Engineering contains several articles of interest. On account of lack of space only a brief reference could be given to the description of the boiler plant at the International Exhibition of Printing and Graphic Arts at Leipzig designed to burn exclusively lignite briquettes. In the next abstract Winkelmann discusses the influence of firing-up processes on the life of tubular boilers with withdrawable smoke-tubes, and various ways of preventing the rise of stresses due to difference between the temperature of water and boiler metal. Schömberg gives data on the application of large straight flow steam engines in metallurgical plants, chiefly in various types of rolling mills.

In the section Strength of Materials and Materials of Construction, are reported articles on the influence of the presence of notches on the strength of machine parts. In the course of this article mention is made of the work of Doctor of Engineering Preuss. We are sorry to announce that this writer, whose work has been referred to before in the Engineering Survey, has been recently killed in the war in Europe. In the next article in the same section, Weiss, in investigating the process taking place in upsetting of metal cylinders, calls attention to a rather striking phenomenon, viz., the formation of an internal core and an external ring surface, the appearance of latter, especially in the case of copper-manganese alloy, being essentially different from the core metal.

In a paper before the American Institute of Mining Engineers S. S. Rumsey and W. F. Schwedes describe a test of centrifugal motor-driven pumps.

An abstract of papers presented before the Engineers' Society of Western Pennsylvania on the measurement of the velocity of flowing water was given in the Engineering Survey for last month. These papers have led to a discussion of unusual interest, an abstract of which is given this month. An abstract of another paper presented before the same society, by C. L. W. Trinks on air in jet condensers, is likewise given this month, with such portions of the discussion as the space available permitted of using.

Of the papers presented to the autumn meeting of the Iron and Steel Institute abstracts are given of three papers of interest to the mechanical engineer: the decarburization of steel in the salt baths used for heating previous to hardening, where it is shown that a mixture is available which secures a perfect equilibrium, with respect to carbon in the bath, to such an extent that it is possible to obtain simultaneously, in the same bath, the decarburization of hard steels and the carburization of dead-soft steels. Walter L. Johnson, in a paper on the utilization of heat contained in slags in steam turbines, shows that while blades are available which are but little affected by steam produced from the hot slags, the direct method of steam utilization is not convenient on account of the tendency of sulphur deposit to clog the turbine passages, and a water heater or heat exchanger has to be used. He found that with proper equipment and without a heavy increase of cost of operation or initial investment, there may be obtained 31.6 h.p. per hour per ton of slag per hour. In this connection will be also of interest the paper by T. Rolland Wollaston before the Society of Chemical Industry on power costs in various works, showing that it is actually possible not only to obtain power free of cost, but to have a profit of 21 per cent on the capital outlay. This is possible with a Mond system peat gas recovery plant, the disadvantage of which is, however, that its capital cost is extremely high, approximately $210,000 for a plant of 2,000 h.p. There may yet come a day when all power used by the industries will be only a by-product of manufactures, chemical works, blast furnaces, coal products utilization, etc.

In connection with the abstract from the Professional Memoirs, Corps of Engineers, U. S. Army, in the October

issue of *The Journal*, p. 201, describing a type of rope fastening, Mr. F. W. Trabold, member of the Society, writes that he has found the drop-forged wire rope socket with the strands of the cable separated and then babbited to be a reliable type of construction. With the strongest wire rope the cables almost invariably parted before the sockets did, sometimes close to the socket, and sometimes at a considerable distance from it, which is of interest as the separation of the rope at some constant point might indicate weakness created in the given portion of the rope through the particular construction of the socket. As regards the comparative cost of splicing and babbiting, the writer points out that the labor of splicing is considerably more costly than that of babbiting the cable in the socket; while the socket itself is considerably more costly than the thimble, there is a final economy owing to the lower labor cost. Further, while the socket is more costly than the clip and thimble combined used in the splicing method, in the latter 18 in. additional cable is required which practically equalizes the matter of cost. As regards the strength of drop-forged wire rope sockets the writer states that with alloy steel plugs the socket on the $1\frac{1}{4}$ in. size pulled strains of 149,700 lb. without injury.

FOREIGN REVIEW

Internal-Combustion Engineering

Remarks Concerning Double Acting Two Stroke Cycle Engines (*Bemerkungen über doppelwirkende Zweitaktmotoren*, Max Hofmann, *Dinglers polytechnisches Journal*, vol. 329, no. 38-39, p. 575, September 26, 1914, 3 pp., 3 figs., *g.*). The article discusses the difficulties of design and construction of double acting two-stroke cycle engines. It is not sufficiently realized, according to the author, that the main essential requirements of this type of engine, that, commercially, it can be built only in large sizes—is opposed by the difficulty of overcoming the stresses caused in the large cylinder castings by expansion due to unequal heating. A complicated engine cylinder in which the liner and cooling water jacket are cast in one piece and which carries on top and bottom, a second jacket for the scavenger air connections, is just the kind of construction that is likely to show cracks in it immediately after it is set in operation. The jackets by no means increase the strength of the cylinder in the axial direction. On the contrary, the working walls of the cylinder come in contact with the burning gases and attain a high average temperature while the exterior jacket, on account of the flow of water, remains cool, this combination leading to the rise of great axial stresses and possible rupture of the cylinder. It has been recommended to use special liners or to put in, either by threading or by rolling in, special steel tubing for scavenger air valve support. This is, however, not mechanically convenient, since the heat expansion of the liner and the displacement of the threaded-in or rolled-in connection would very rapidly develop leaks at places.

The design of scavenger valves is also a difficult problem. Horizontal valves are only used seldom, the Körting type being the only one on the market. In order to obtain a disc-shaped combustion space, this type is willing to suffer the operating difficulties of this type of valve arrangement. With it, the scavenger valve pockets have to be so deep as to raise very materially the clearance space at the end of the compression stroke. As shown in Fig. 1 (upper connection-admission of scavenging air, lower connection for exhaust), the double acting engine of this type gives approximately 20 per cent of the combustion space to pockets necessitated by the horizontal valve arrangement and since the piston in its final position covers over these pockets to a large extent, the air contained therein is late in coming in contact with the entering fuel, and is apt therefore to produce after-burning of the charge, in addition to which the horizontal position of the valve is apt to produce incomplete scavenging.

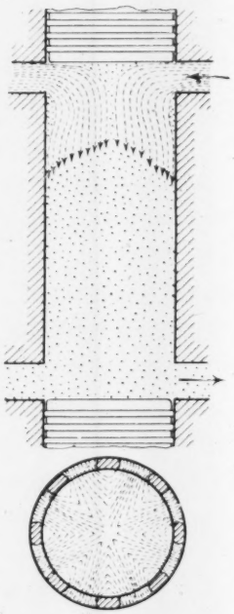


Fig. 1 Double Acting Two Stroke Cycle Engine Cylinder

Machine Shop

Testing of Compressed Air Twist Drills in the Royal Shipyards at Kiel (*Erprobung von Spiralbohrern für den Pressluftbetrieb auf der Kaiserlichen Werft Kiel*, T. Schwarz, *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 33, p. 1336, August 15, 1914, 4 pp., 6 figs., *de.*). The article presents a description of an installation for the purpose of testing twist drills, and indicates how from the data of such tests one is enabled to determine the most advantageous grades of steel for the various kinds of work. Until the time when twist drills have been produced from high speed steel, the latter had quite a limited application in shipyards. Even now, in the case of high speed steel, one has to consider not only the price of the material, but also its range of application. While high speed steel has been proven capable of excellent work for drilling purposes, it seems to be far less applicable for dies and stamps for compressed air riveting. Further, the number of grades of high speed steel used in shipyards increases rapidly with the range of application, and since each grade of steel requires the use of peculiar methods for its handling and hardening, the proper selection of tool steels becomes a matter of considerable difficulty. The further difficulty of buying these supplies for government shipyards by open competition led to the development of a system of ordering tool steel by indicating the purpose for which it was to be used.

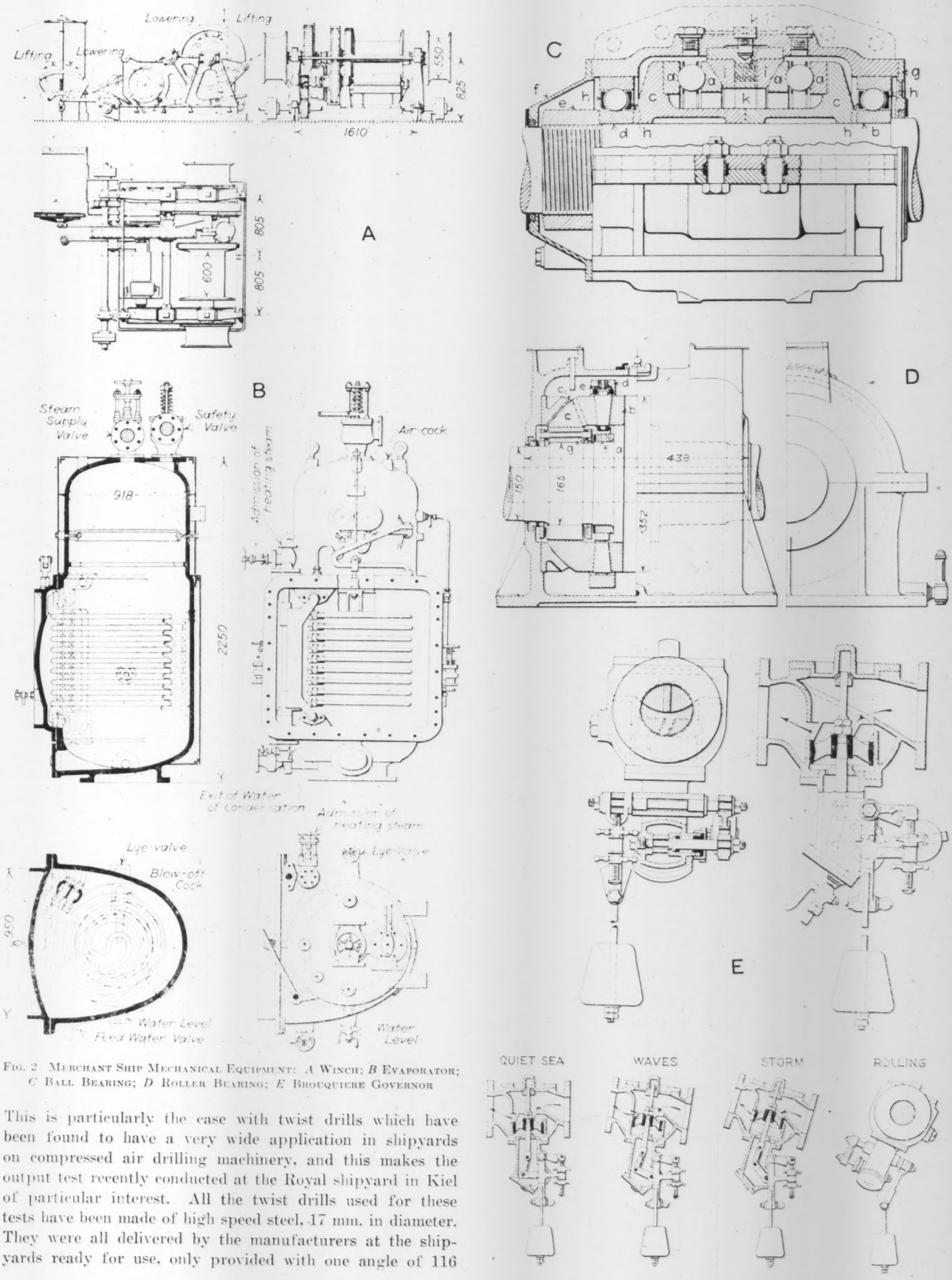


FIG. 2 MERCHANT SHIP MECHANICAL EQUIPMENT: *A* WINCH; *B* EVAPORATOR; *C* BALL BEARING; *D* ROLLER BEARING; *E* BROUQUIERE GOVERNOR

This is particularly the case with twist drills which have been found to have a very wide application in shipyards on compressed air drilling machinery, and this makes the output test recently conducted at the Royal shipyard in Kiel of particular interest. All the twist drills used for these tests have been made of high speed steel, 17 mm. in diameter. They were all delivered by the manufacturers at the shipyards ready for use, only provided with one angle of 116

deg. The article shows the arrangement of the testing apparatus and gives the data obtained in the tests, among other things curves of output for various types of high speed steel twist drills.

Modern Auxiliary Machinery and Installations on Merchant Ships (*Neuere Hilfsmaschinen und Einrichtungen für Handelsschiffe*, W. Kaemmerer, *Zeits. des Vereines deutscher Ingenieure*, vol. 58, serial, *d.*). The article describes modern auxiliary machinery and installations on a merchant ship. Among other things described is a special winch for use on boats to serve simultaneously for hoisting provisions, coal and boats. It is shown in Fig. 2A and is operated by a 24 h.p. 200 ampere 140 volt direct-current motor, driving at 590 r.p.m. the main shaft of the winch which serves for hoisting provisions. On an extension of the shaft, there is a capstan head to take care of the coal baskets; further, there is a train of two spur gears, driving at 700 r.p.m. a transmission shaft for the Welin boat davits. The handling of the winch is extremely simple. The load is lifted by a single hand lever, while a foot lever actuates a braking electric magnet. The winch lifts a load of 2 tons at a speed of 0.75 meters (29.5 in.) per second.

The author describes further an evaporator (Fig. B) which is said not to have been previously described anywhere. It has a heating area of 5.9 q.m. (63.5 sq. ft.). The sea water enters at *a* and flows around the copper serpentine *b*, through which passes the steam from the boilers or receivers. The salt deposited during the above operation is let out through a valve *c*; steam obtained from the sea water moves forward and is let out through the valve *d*. In the upper part of the condenser there is a preheater and trap *e*, the purpose of which is to eliminate from the steam the water particles. The copper serpentine can be easily taken out by removing a single cover and easily cleaned, which would be necessary quite often as the salt has a tendency to deposit on the copper.

Fig. C shows a pressure bearing designed for propeller shafts by the German Arms and Ammunition Factory in Berlin. Its construction is characteristic through the fact that both the radial and axial pressure on the shaft is taken up by ball bearings. The ball bearing *a* is placed in a strong housing of steel casting reinforced by ribs in which the races are adjusted on both sides. One ball race bearing *b* presses on one side against a shoulder on the shaft and on the other hand is held by a divided intermediary piece. The other ball race bearing *d* presses against the intermediary piece by a nut *e*. After the cap-shaped cover *f*, placed on top, is removed, the housing becomes easily accessible. On the other side, the housing is closed by an ordinary flat cover. Both covers are packed with respect to the shaft by felt rings. The balls are held in the bearings by the casings *h* made of brass; both footstep bearings *a*, kept in place by the intermediary piece *c*, are provided with foot rings pressing against the base plate *i*, and have automatic adjustment to meet bending of the shaft. From the base plate, the footstep pressure is transmitted by means of the intermediary ring *k* held rigid in the housing. On the side free of load there is an air gap of 0.25 mm. (0.009 in.) between the base plate and the intermediary ring. The base plate also takes up the pressure of a number of vertical spiral springs uniformly distributed around the periphery. The balls of the bearings are held in casings of sheet brass. The oil used for lubrication must have such a high level in the bearing that the balls in the races should be under oil up to one half. This can be observed from the outside by means of glass tubes. The balls of the fundamental bearing run also constantly in oil. The axial pressure taken up by such ball bearings amounts to 800 kg. (1763 lb.) at 450 r.p.m.

The roller bearing of the Moffet type to take up axial pressure of the propeller shaft, as built by the Atlas works in Bremen, is shown in Fig. D. The pressure shaft has only one connection *a* over which is placed, on each side, a hardened ground ring *b* to take up the alternations in the direction of the pressure during the forward and backward motion. From these two rings the pressure is transmitted upon a special bearing by means of a number of conical rollers, either in one direction or another, through two spherical rings *c* and *c'*, gripping into one another. The conical rollers are held in a rigid casing *d* on both sides of the cam, but each roller is individually adjustable by means of the device shown at *e*. Each of the roller casings is steered along the shaft by means of a bronze ring *f*, while the weight of the pressure shaft itself is taken up by the cylindrical rollers *g*, which in their turn, are located in a rigid frame. Small bolts are used for guiding the individual rollers along the shaft, provided with such an amount of play that they do not take part in the transmission of the pressure.

The article further describes the construction of the Brouquière governor, the advantage of which is that it is claimed not to permit racing of the engine. Its construction is said to be extremely simple and is shown in Fig. E. As close as possible to the valve of the pressure cylinder, is built in the steam piping, a special governor valve, the housing of which (made of bronze, cast iron or cast steel), contains a cylindrical guide with slots. These slots, and consequently the steam admission to the engine, are opened or closed as necessary, by means of a piston rod which, as shown in Fig. F, is moved in such a manner that as soon as the level of the ship changes longitudinally, a pendulum begins to act on a knee lever transmission, this action taking place, however, only when the ship changes its position in a longitudinal direction; if the ship starts to roll, the pendulum oscillates without affecting the steam stop valve, the position of which may be further adjusted by means of a special spindle. The action of the governor may be seen from Fig. G.

Mechanics

Calculation of Worm Gear Drive for Rear Axles of Power Wagons (*Berechnung des Schneckenantriebes für Kraftwagen-Hinterachsen*, A. G. von Loewe, *Der Motorwagen*, vol. 17, no. 21, p. 501, July 31, 1914, 4 pp., *mp.*). In calculating the worm gear drive for the rear axles of power wagons, the gear ratio $\ddot{U}$ and the normal modulus may be assumed to be known. The following conditions must be satisfied by the worm gear drive: (1) a very high efficiency, in good execution about 97 per cent; (2) possibility of reversing without materially increasing the work of friction; (3) no danger of seizing between surfaces sliding under pressure. The fulfillment of these conditions is affected principally by the angle of inclination of the worm, the selection of which must be therefore made with the greatest care. To determine the efficiency, and consequently the friction losses, one has to start from the conditions of equilibrium of the worm gear drive. Let A_m = the work of driving, A_f = work of friction, A_r = work transmitted; then:

$$A_m = A_r + A_f \text{ and } A_r = A_m - A_f.$$

If α is the angle between the thread and the generating line of the cylinder of the gear, and $\mu = \tan \varphi$ the coefficient of friction, then:

$$A_r = \frac{A_m}{\sin \alpha} \frac{\mu}{\cos \alpha + \mu \sin \alpha}$$

$$A_f = A_m \frac{\mu(1 + \tan^2 \alpha)}{\tan \alpha (1 + \mu \tan \alpha)}$$

The efficiency η_0 is:

$$\eta_0 = \frac{A_r}{A_m} = \frac{\tan \alpha - \mu}{\tan \alpha (1 + \mu \tan \alpha)}$$

By differentiating this expression in α, we find that η_0 is a maximum when

$$\mu(1 + 2\mu \tan \alpha - \tan^2 \alpha) = 0$$

and hence:

$$\tan \alpha = \mu \pm \sqrt{\mu^2 + 1}$$

If we substitute for μ in this expression some number C, and then determine the value of α, it will always be, provided $\mu = \tan \alpha$,

$$\alpha = 45 + \frac{C}{2}$$

and therefore the best efficiency will be obtained from a worm and worm-wheel with an angle of inclination:

$$\alpha = 45^\circ + \frac{C}{2}, \text{ or } \alpha' = 45^\circ - \frac{C}{2}.$$

In the case of motor cars such wheels cannot be applied, however, because their diameter is approximately proportional to the gear ratio, and the drive would therefore have too large dimensions. When the angle of inclination is $45^\circ - \frac{C}{2}$ the friction in reversed drive is approximately equal to that of direct drive; the smaller the angle α, the larger are the friction losses in reverse drive, until at $\tan \alpha = \mu$ seizing takes place.

According to data collected by Ader for the *Automobiltechnisches Handbuch*, there is the following relation between the admissible normal tooth pressure P_n (in kg.) and the sliding speed v_g (in meters per sec.):

v_g	125	2	2.5	3	4
P_n	600	375	300	240	150

In the same reference book a table is given which indicates that the greater the number of turns of the worm, the smaller are the friction losses in the worm gear drive.

The forces acting in the gear are determined in the following manner. The following notation is used:

M_m the maximum moment of torsion transmitted in kg. per cm.;
d diameter of pitch circle of worm, in cm.;
P tangential pressure at the pitch circle of the worm, in m. per kg.;
P_1 transmitted tangential effort at the pitch circle of the worm wheel in m. per kg.;
P_n normal tooth pressure in kg.;
α angle of inclination in deg.;
μ coefficient of friction;
η efficiency of the worm gear drive;

If the worm drives the gear,

$$P = 2\frac{M_m}{d}$$

where d can be determined graphically. Further:

$$P_1 = P \frac{\tan \alpha - \mu}{1 + \mu \tan \alpha}, \text{ or } P_1 = P \frac{\tan \alpha - 0.08}{1 + 0.08 \tan \alpha}$$

the latter with $\mu = 0.08$. The normal tooth pressure is

$$P_n = \frac{P}{\cos \alpha + \mu \sin \alpha} \text{ and } P_n = \frac{P}{\cos \alpha + 0.08 \sin \alpha}$$

the efficiency is then:

$$\eta_1 = \frac{\tan \alpha - 0.08}{\tan \alpha (1 + 0.08 \tan \alpha)} \text{ and } \eta_1 = \frac{\tan \alpha - 0.08}{\tan \alpha + 0.08 \tan^2 \alpha}$$

In order to determine the permissible tooth pressure as a function of the sliding speed, the pressure at the greatest sliding speed that may occur has to be determined, since, as shown in the above table, with increasing sliding speed, the pressures P_n invariably decrease, while the moment of torsion is inversely proportional to the speed of rotation. The greatest sliding speed occurs when the worm runs at the speed n of the engine. The tangential pressure which then occurs at the pitch circle of the worm is:

$$P_m = 2\frac{M}{d}$$

where M is the moment of torsion of the engine. The normal tooth pressure is then:

$$P_{nm} = \frac{P_m}{\cos \alpha + 0.08 \sin \alpha}$$

The maximum tangential speed at the pitch circle of the worm is:

$$v = \frac{\pi d.N}{100.60} = \frac{d.N}{3600} \text{ meters per sec.,}$$

where N is the highest speed of the engine. The sliding speed is

$$v_g = \frac{v}{\sin \alpha}$$

The values of P_{nm} and v_g must satisfy the requirements of the table. A similar calculation must be carried out also for a reversed drive under the above most unfavorable assumptions. Let P'_1 be the tangential resistance to be overcome at the pitch circle of the worm, in kg.;

P' tangential pressure at the pitch circle of the worm wheel, in kg.;
P'_n normal tooth pressure in kg.;
M moment of torsion of the engine in cm. per kg.; then the following relations are good:

$$P'_1 = \frac{2 \times 0.65\, m}{d} = 1.3\frac{M}{d}$$

$$P' = P'_1 \frac{\tan \alpha + \mu}{1 - \mu \tan \alpha}, \text{ and } P' = P'_1 \frac{\tan \alpha + 0.1}{1 - 0.1 \tan \alpha}$$

and the normal tooth pressure is

$$P'_n = \frac{P'}{\sin \alpha + \mu \cos \alpha} \text{ and } P'_n = \frac{P'}{\sin \alpha + 0.1 \cos \alpha}$$

the efficiency being:

$$\eta_1' = \frac{\tan \alpha (1 - \mu \tan \alpha)}{\tan \alpha + \mu} \text{ and } \eta_1' = \frac{\tan \alpha (1 - 0.1 \tan \alpha)}{\tan \alpha + 0.1}$$

Since in the case of reversed drive the relation between resistance (or tooth pressure) and speed of rotation (or sliding speed) are different from that in the case of direct drive, and there is no apparent proportionality between the two, it is necessary to determine it for the two extreme cases, that is, maximum normal tooth pressure and maximum sliding speed. In the first case $P'_{nm} = P'_n$, and

$$v' = 1.5 \frac{z.z_1.N.d.}{Z.Z_1.3.00} \text{ meters per sec.,}$$

where z, z_1, Z, Z_1 are the numbers of teeth of the driving wheels in engagement at the smallest gear ratio.

$$v'_g = \frac{v'}{\sin \alpha}$$

At the greatest sliding speed the resistance at the pitch circle of the worm is:

$$P'_o = 0.2 \times 2\frac{M}{d} \times 0.4\frac{M}{d}$$

and the tangential pressure at the pitch circle of the worm wheel is

$$P'_o = P' \frac{\tan \alpha + 0.1}{1 - 0.1 \tan \alpha}$$

Hence the normal tooth pressure is:

$$P'_{on} = \frac{P'_o}{\sin \alpha + 0.1 \cos \alpha}$$

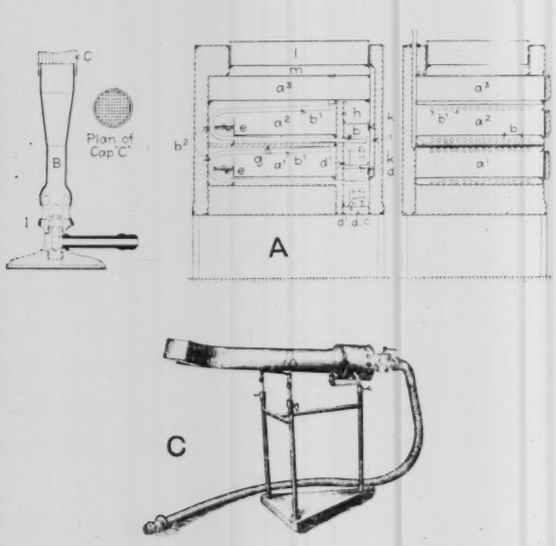
and the sliding speed appears to be equal to

$$v_g = \frac{v}{\sin \alpha.}$$

From this the author proceeds to the determination of various dimensions of the worm gear drive.

Ovens

Steam and Gas Fired Bakers' Ovens (*Dampf- und Gasbacköfen,* Pradel, *Zeits. für Dampfkessel und Maschinenbetrieb,* vol. 37, no. 38, p. 435, September 18, 1914, 3 pp., 11 figs., *d.*). The article describes various types of modern steam heated and gas fired bakers' ovens, mainly those shown



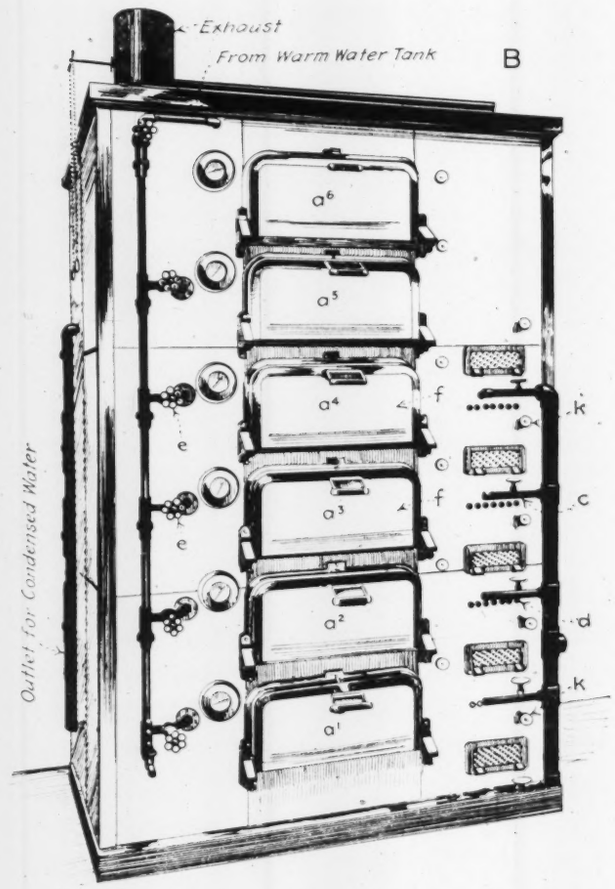


Fig. 3 Bakers' Ovens and Heaters for Same

at the recent Gas Exhibition in Munich, Germany. After giving a general statement of the principles on which the construction of this kind of bakers' oven is based, the author describes several types of such ovens. Of late, gas firing was applied to steam heated bakers' ovens, e.g., in the Senking type of oven. It was constructed mainly for use in small bakeries. As shown in Figures 3 A and B, the Senking oven consists in the downward direction of four double walls and in the lateral of two double walls, insulated so as to prevent losses through heat radiation. In order to save floor space, the oven is built vertically and has from 2 to 6 decks, one over the other. This arrangement is of particular advantage for large cities where floor space considerations are of importance. Figs. A and B show two sections of a 3-decks oven at right angles to one another. Fig. C shows a similar 6-decks oven which gives an idea of the oven equipment. The oven is constructed in such a manner that each deck singly and all the decks together may be operated as desired. These single decks are accessible through doors *f*. When a 3-decks oven is used, two systems of piping are employed—one in each of the two lower decks, a^1 and a^2, divided from one another by means of the wall *g* and from the heating space by the wall *h*. Through this latter wall pass the ends of the steam pipes *b* which have to be heated. The heating pipes are U-shaped and are located in such a manner that their lower bend lies on the floor of the decks under the drawplate, while the upper bend b_1, which joins the upper bend b_1, goes under the deck cover nearly to the wall *h*. The decks a_1 and a_2 are therefore provided with heat from above and from below, while the deck a_3 is provided only with heat from below. As a rule, all appliances on the oven, as well as the gas cocks, are placed as far as possible on the front part so that the attendance may be easy and convenient. In the heating space of the oven between the wall *h* and the external wall are located the gas pipes for the different decks operated by cocks placed on the outside. The air of combustion enters from below out of the air chambers *d* and reaches the flame through the openings d_1, while a supplementary amount is admitted through the screen doors which serve for igniting the gas and for cleaning.

As the combustion of gaseous fuels can be regulated in

such a manner as to produce a flame free from soot, indirect heating of baking ovens by gas does not appear to be necessary, and the oven may be heated by the gas flame direct. It is possible therefore to easily convert a wood fired oven into a gas oven by simply using a suitable burner. The Méker burner used in this connection is really nothing but an improved Bunsen burner, Fig. D. It consists of a pipe through which the gas is driven by the injector *I*, provided with a calibrated opening. Over this injector is screwed the chimney *D*, provided at the bottom with holes, and closed at the top by a cellular body *C*, perforated by passages and having the purpose of preventing backfiring and also of producing a uniform flame. As shown in Fig. E, the nozzle of the burner is forked, in order to allow the flame to play over the entire width of the oven. The burner is made of heavy steel sheeting and welded autogenously so as to leave no spaces which are not gas tight. The cellular body *C* is made of nickel-steel strips. The burner is supported on a wheel truck and connected with the gas piping by metal hose so that it can be pushed into the oven when the fire is started and taken out again. The question whether several smaller or one large gas fired oven is more economical is as yet undecided and experimental data are lacking. In view of the easy attendance on a gas fired baking oven and its simplicity, however, it would appear that a larger number of small ovens would in the end prove more economical for large outputs than one large one. An oven of which the author holds a high opinion has been shown at the Exhibition. In order to obtain as uniform heating in the entire oven space as possible, the burner is built in along the three sides of the oven space; viz., by the side of the superimposed deck plates and below the lowest plates. In this way the properties of gas heating are said to be especially well utilized and the heat conducted directly where it is most useful. The article goes into some detail of this construction, but does not illustrate it.

Pumps

Oil Driven Engine-Pump Aggregate (*Groupe motopompe fonctionnant au pétrole, Portefeuille économique des machines*, vol. 2, series 6, no. 702, p. 81, June 1914, 2 pp., 2 sheets of drawings, *d*). The article describes a direct-connected aggregate of a motor and pump, the motor being a four cylinder shale-oil engine, 130 mm (5.1 in.) bore and 160 mm (6.2 in.) stroke, developing at 1000 r.p.m. about 41 h.p. The motor is provided with an Aster carbureter heated by the exhaust gases, and high tension Bosch magneto ignition. For special reasons it was desirable to have the aggregate occupy as little space as possible. As however the pump ran at 450 r.p.m. a reduction of speed was necessary, but as there was no room for extending the motor shaft, an epicycloidal transmission was resorted to, the flywheel being made hollow. The pinion clamped on the shaft of the pump has in its turn such a diameter this it is located exactly between the speed reducer and the interior of the rim of the flywheel, consequently the entire apparatus for the reduction of the speed is placed inside the flywheel without increasing the space occupied by the aggregate.

Steam Engineering

Boiler Plant at the International Exposition of Printing and Graphic Arts at Leipzig in 1914 (*Die Dampfkesselanlage auf der Internationalen Austellung für Buchgewerbe und Graphik, Leipzig* 1914, A. Adler, *Zeits. des Bayerischen Revisions-Vereins*, vol. 18, no. 14, p. 135, July 31, 1914, 3 pp., 20 figs., *d.*). The article presents a description of the boiler plant of the power-house at the International Exhibition of Printing and Graphic Arts, Leipzig, in 1914. The triple flue tubular boiler had a heating area of 425 qm. (4574 sq. ft.), a gage pressure of 14 atmospheres and a superheater installed in the flues for a steam temperature of 350 deg. cent. (662 deg. fahr.). One of the conditions adopted by the technical board of the exhibiton was that the boiler should use exclusively lignite briquettes, which had to be taken into consideration in designing the grate. On top of the jacket of the upper header, there is a steam dome of 800 mm. (31.4 in.) in diameter and 800 mm. (31.4 in.) high. In it are placed the steam stop valves, a double safety valve and a reserve pipe. At the base of the dome is placed a manhole for the inspection of the interior of the boiler. In addition to this, on the upper header is located an attachment for a signalling apparatus and a water level regulator.

The steam superheater is of peculiar interest; it is arranged in such a manner that only part of the gases developed on the grate pass through it. The regulating valves are placed behind the superheater, which protects them from overheating. In addition to that, the arrangement of the superheater is such that the radiant heat stored up in the brick work in front of the superheater is utilized in the latter. The steam enters into rolled seamless superheater chambers which enclose the superheater tubes; it flows through the superheater in countercurrent to the entering heat gases and from the lower collecting chamber passes into the attached piping back to the triple valve, whence the superheated steam is led to where it is wanted. The employment of the triple valve permits, by a simple adjustment of the steam stop spindle, the use of saturated steam, superheated steam or a mixture of both. The adjustment of this valve can be made from the boiler room floor. Since the triple valves do not permit of seeing simply from the position of the hand wheel what kind of steam is used and which of the steam connections are open or closed, the German Association of Boiler Inspection Societies insists on a second stop valve being placed between the boiler and the triple valve. The rest of the article describes and illustrates the installation in detail.

Measurement of Water Temperature During Firing-Up of Tubular Boilers with Withdrawable Firetubes (*Messung der Wassertemperatur während des Anheizens von ausziehbaren Röhrenkesseln*, H. Winkelmann, *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 39, p. 443, September 25, 1914, 2 pp., *p.*). The article describes the methods of regulating the temperature of water during the firing-up of tubular boilers with withdrawable smoke tubes. In tubular boilers, leaks in the seams start quite often during the firing-up process, and even the lower rows of tubes seem to be affected in the same way. As a rule, this kind of leak appears the more frequently, the cooler the season, the colder the feed water and the more rapidly the firing-up process is carried on. It may be ascribed therefore to the considerable stresses created in the boiler sheets by the temperature difference between the various boiler parts and the water in the boiler during the firing-up period, and to the fact that with the usual boiler construction, there is not a sufficient circulation of water. It has been attempted many times therefore to apply special devices for speeding-up the

water circulation and equalizing as far as possible the heating of the water in the various parts of the boiler. This appears of the greater importance, in view of the fact that quite a large number of boiler accidents were recently ascribed to the incorrect heating of the lower parts of the boiler with withdrawal tubes. It has happened repeatedly that blow-off tubes have been torn off and fire tubes have developed leaks through which boiler attendants have been either injured or placed in danger of injury.

The experiments described in this article have been made with a purpose of seeing to what amount the devices for producing rapid equalization in the heating up of the water are defective. Tests were made on three locomobiles of commercial types and various sizes, all with withdrawal tubes. In the first test, the heating up was made in a normal manner without the use of any heat equalizing device. In the second case, the heating up was carried at as rapid rate as possible with the help of an exceptionally experienced fireman, but no equalizing devices were used. Finally in the third test, both heat equalizing devices and exceptionally rapid firing up were used together or singly. The equalizing devices used were a special type of injector which sucked in water and delivered it through a 3-way pipe of which the three branches were in the lowest part of the boiler—one in front, another in the middle and the third in the rear of the boiler. The second equalizing device was a Howald temperature equalizer, which has a serpentine of special construction. Complete data of tests are given in a table in the article.

It appears that the heat equalization produced by means of the injector is superior to that produced by a serpentine, but the latter has the advantage of working automatically and does not have to be under constant supervision, contrary to the case when the injector is used. Both devices begin to act only after the steam begins to be generated and up to that instant, in both cases, the boiler remains subjected to the great stresses produced by temperature differences. The instructions generally given by the manufacturers of tubular boilers with withdrawable tubes, to the effect that during firing up a part of the boiler, water should be let out by the blow-off cocks, is at best only an emergency measure. The best method of protecting the boiler, which unfortunately, however, can be applied only in a limited number of cases, is when starting it up to fill it with water previously heated to 212 deg. fahr. It appears also that the device proposed by Altmayer for use on modern boilers and locomobiles may be applied for improving water circulation also in tubular boilers. Although it does not begin to operate right from the start of the firing-up process, it acts at an earlier period than the serpentine device. The author comes to the general conclusion that the manufacturers of tubular boilers ought to pay more attention to making their product safer in operation and more economical.

Large, Straight Flow Steam Engines in Metallurgical Plants (*Grosse Gleichstromdampfmaschinen für Hüttenwerke Schömberg, Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 35, p. 411, August 28, 1914, 2 pp., *p.*). The article discusses the application of large, straight flow steam engines in metallurgical plants. The great advantages of this type lie in its reliability, simple attendance, low steam consumption, limited floor space requirements, ability to carry large overloads and exact regulation, unlike, in the latter regard, compound engines. During the last few years they have been rapidly introduced for direct drive on rolling mills, in particular for three-high rolls where, notwithstanding a large variation in output, a constant speed of rotation is necessary. A compound engine with a large, low pressure cylinder and a complicated method of control, would satisfy this requirement only at the cost of a large expenditure in power, and even then no reliance could be placed on it. The flywheel, even though of very generous dimensions and run at the peripheral speed up to 35 m. (114.8 ft.) per second, would not fully equalize the varying load, and in addition to that, the overload capacity of a compound engine is quite limited.

Table 1 gives some data about the larger works where rolling mill drives by straight flow engines has been introduced. In the case of some of these engines, very high piston velocities appear to be used (up to 5.5 m. (18 ft.) per second) without any damage to the installation and without unfavorably affecting the operation of the machinery. Tandem engines of similar dimensions would not permit this being done. The initial cost of the engine is said to be on an average of from 20 to 30 per cent lower than that of the tandem engines of equal size and equipment. To this must be added the saving in cost of foundation—about 10 per cent. The cost of operation is said to be very low; the average consumption of steam, in the case of engines rated at about 1500 h.p., at 10 atmospheres pressure and 250 deg. cent. (482 deg. fahr.) temperature, vacuum of 88 to 90 per cent and 90 per cent mechanical efficiency of machinery, may be counted on at 5.8 to 6 kg. (12.8 to 13.2 lb.) of steam per effective h.p.h. in the case of normally working rolls, or including condensation and losses in the condenser, 6.5 kg. (14.3 lb.) at the shaft of the rolling mill. Since good tandem engines in continuous operation have shown a steam consumption of 8.9 kg., the saving in steam appears to be around 25 per cent. In addition to that must be considered the economy in lubricating materials due to the absence of one cylinder and its valve gear.

Of particular interest are the extra large engines marked as 9 and 10 in the table. No. 9 has been put in to take the place of a tandem engine, which used to drive a beam and rail rolling mill at a consumption of 10 kg. (22 lb.) of steam. Although the plant has at its disposal a cheap source of electrical energy, it has been decided to drive the rolls by steam and not by electric motor. The engine works with steam pressure of 7 to 8 atmospheres, which it is proposed to increase to 12 atmospheres. Extensive tests of steam consumption have after a considerable period of operation shown the consumption without condenser losses to be 5.3 kg. (11.6 lb.) per indicated h.p.h. at a load of about 3000 h.p., with 7 atmospheres pressure, 300 deg. cent. superheat and 9 per cent vacuum. The engine marked at No. 10 is used on a modern high efficiency rolling mill.

Experiences in Electric and Autogenous Welding of Steam Boilers (*Erfahrungen über elektrische und Autogenschweissungen an Dampfkesseln. Zeitsch. für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 25, p. 303, June 19, 1914, 2 pp. *cp*). The article is a report of papers read at the 43rd meeting of delegates and engineers of the International Association of Boiler Inspection Societies by Münster and Eggers, on the subject of experiences in electric and autogenous welding of boilers. Experience has gener-

ally shown that autogenous and electric welding are approximately of equal value, although it may be stated that electric welding is somewhat preferable on account of more limited local heating of the material. Both processes are being introduced in the construction of boilers and so far have been used only in the case of small vertical boilers, mostly fire-tube type in which the fire tubes and partly the bottoms are welded in. It appears further that both kinds of welding are justified on parts subject only to compression stresses and only quite small and temporary tension stresses. The welds must be executed only by fully reliable concerns and no hammering on the welded seam, when blue heat has been applied, should be allowed. Mr. Eggers stated that in Germany electric welding on steam boilers, steam containers and general steam apparatus under stresses is comparatively little used as compared with welding by the acetylene-oxygen flame, but has been widely introduced in Russia and found its way to Western Europe from there. In repairs on steam boilers acetylene welding is still widely used, but many of the steam inspection societies in Germany are gradually coming to the use of electric welding.

TABLE 1 DATA OF LARGE STRAIGHT-FLOW ENGINES IN METALLURGICAL PLANTS

No.	Name of Plant	Kind of Mill	R.p.m.	H.P.	Dimensions
1	Burbach	small section rolling mill	90 to 130	700 to 1000	43 in. stroke
2	Ph. Weber, Hostenbach	sheet rolling mill	60 to 70	800 to 1000	rebuilt from tandem engine, 49 in. stroke
3	Rombach	structural iron rolling mill	90 to 120	1600 to 2200	41 in. bore, 51 stroke
4	Siegen Iron Works	middle roll	60 to 100	1900 to 1200	43 in. stroke
5	Dusseldorf Iron and Wire Co.	small section and wire mill	90 to 100	800 to 1150	43 in. stroke
6	Dusseldorf Iron and Wire Co.	wire mill	100 to 110	1500 to 1900	51 in. stroke
7	Hahn Works, Grossenbaum	universal rolling mill	85	1600 to 2200	rebuilt, 51 in. stroke
8	Konigin-Marienhutte, Saxony	small section rolling mill	80 to 100	1000 to 1300	47 in. stroke
9	Rochling Steel Works	beams and rails, 28 in. diameter	110	4000 to 6200	66.9 in. bore, 55 in. stroke, 8 atmospheres
10	Westfalian Steel Works, Aplerbeck	wire mill	100	3000 to 4500	57 in. bore, 59 in. stroke, 12 atmospheres
11	Bros. Stumm, Neunkirchen	structural iron rolling mill	80 to 120	2400 to 3200	37.4 in. bore, 51 in. stroke, 9 to 10 atmospheres

Strength of Materials and Materials of Construction

Notch Action in Machine Parts and Boiler Sheets (*Die Kerbwirkung bei Maschinenteilen und Dampfkesselblechen, Zeits. des Bayerischen Revisions-Vereins,* vol. 18, nos. 15 and 16, pp. 150 and 157, August 15, and 31, 1914, 4 pp., 9 figs., *tp.*). The article discusses the influence of the presence of notches on the strength of machine parts and boiler sheets. In a paper On the Influence of Notches on the Strength of Machine Parts, presented some time ago by Professor Heyn, of the Royal Testing Laboratory in Grosslichterfelde, he expresses the fundamental law of the action of notches in the following way:

"Notches act as local powerful intensification of stresses."

Some time previously, Doctor of Engineering Preuss extended the same view to the case of the metal surrounding holes and notches in boiler plates and has shown in particular the obnoxious influence of hand punching or caulking. The harm done to boiler plates in the process of knocking off scale belongs to the same class, since indentations made on the plate by sharp instruments are nothing but notches and have all the harmful consequences of them as regards the distribution of stresses in the plate. Professor von Bach has repeatedly called attention to the fact that cracks in boiler sheets can be ascribed to indentations originally produced in knocking off boiler scale. Further, when the boiler sheets are cut, the action of the shears produces cracks which lead to injuries of the plate. It is always advisable, therefore, to remove the sharp edge of the cut plate. Professor R. Baumann has also called attention to the tendency of small cracks to extend through wrought iron, while Professor Heyn, in the above referred to paper, expresses the opinion that under certain circumstances, apparently quite negligible notches may materially reduce the ability of the plate to withstand repeated stresses. Even indentations as small as those produced by the marking tools as well as quite unnoticeable blow-holes may lead to the development of dangerous notching action.

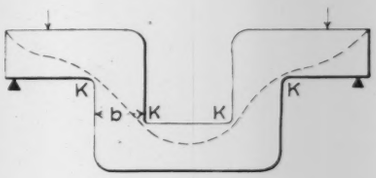


Fig. 4 Distribution of Stresses in a Crank

The article goes into particulars as to the ruptures developed in machine parts due to the initial presence of notches, and shows that slots for cotter for fastening the piston rod to the cross-heads, often become the starting points for ruptures, owing to the notch action. The distribution of stresses along the edges of the slots is just as little favorable as that along the circular edges of a hole in a plate. Among other things, Professor Heyn refers to the extremely illuminating experience of Hoenigsberger, who found that in the case of a crank, the neutral fibre, free of stresses, runs somewhat like a curve (Fig. 4) passing very close to the inner angles *K* on all sides. Professor Heyn states in this connection that the maximum stress will be found at the edges *K*, and it was actually found that the neutral fibre passes close to these edges. Therefore, the edges of the notches in these parts enter to a certain extent into the neutral fibre and the result is that the stresses producing equalization of the moment of torsion are applied with a short lever arm; they are materially larger than those which are connected with the long lever arm at a considerable distance from these angles and experience has actually shown that these angles represent the most endangered part of the crank, and that in the majority of cases rupture occurs in exactly that location.

The above considerations lead the author to emphasize the necessity of the notch shock test for the determination of

strength of materials and proper construction of notching parts.

Alteration of Shape Taking Place in Upsetting of Metal Cylinders (*Der Umformungsvorgang beim Stauchen von Metallzylindern*, L. Weiss, *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 36, p. 1376, September 8, 1914, 2 pp., 6 figs., *e.*). The present article contains illustrations and some new data concerning the processes taking place during the upsetting of cylindrical metal bodies. If a copper cylinder is upset under a hammer, there takes place a certain reduction of the height of the cylinder, and there appears at the terminal surfaces of the cylinder a circular area concentric to the edges. During further upsetting, the ring surface between the core circular surfaces and the edge gradually increases. In the case of copper this phenomenon does not appear in a clear manner, but with copper-manganese alloy containing approximately 6 per cent manganese, the internal circular surface comes out with such a sharp difference from the ring surface at the edge that the first impression is that the two are of different metals. In Fig. 5A, the external diameter D and the diameter of the core surface D_0, as they vary with the decrease of height of the cylinder, are shown by respective lines for a copper cylinder, 27 mm. (1.06 in.) in diameter and 54 mm. high (2.12 in.). In Fig. B are shown similar results obtained in the case of a copper-manganese cylinder 24.5 mm. (0.96 in.) in diameter and 49 mm. (1.92 in.) high.

To explain this striking phenomenon, a metallographic test was made. The polishing of the two terminal surfaces and their microscopic investigation has not given any appreciable results. The author found, however, that the displacement of the crystals in the metal was noticeable if a longitudinal cut of the metal was taken since it was found, as shown in Fig. C, for example, that the lines of flow of metal were generally parallel to the longitudinal axis of the cylinder, but that they made a sharp break at the edges and continue to run horizontally. The line of demarkation of the core surface occurs at the point of change of direction or just where the line of flow passes into the horizontal. In Fig. C these points are shown at the lower edge, in little circles; at the upper edge of the cylinder the little white lines indicate the original diameter of the cylinder.

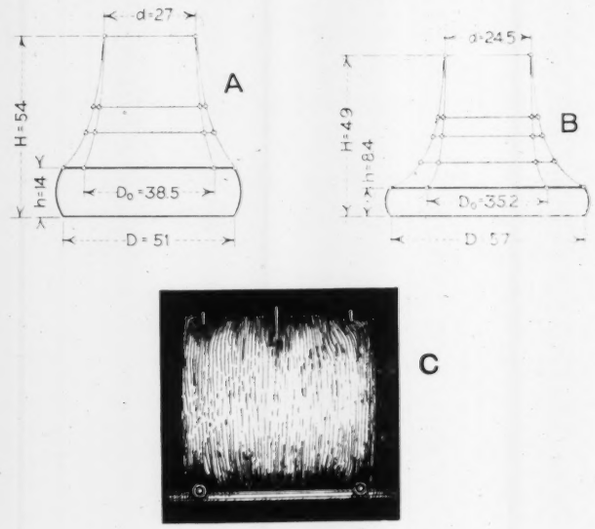


Fig. 5 Upsetting of a Metal Cylinder

ENGINEERING SOCIETIES

AMERICAN INSTITUTE OF MINING ENGINEERS

Bulletin, no. 94, October 1914, New York City

The Safety Movement in the Lake Superior Iron Region, E. Higgins
An Aerial Tramway for Mining Cliff Coal, A. E. Gibson
A New Safety Detonating Fuse, H. Souder
Gasoline Locomotives in Relation to the Health of Miners, O. P. Hood
A Test of Centrifugal Motor Driven Pumps, S. S. Rumsey and W. F. Schwedes (abstracted)

A Test of Centrifugal Motor-Driven Pumps, S. S. Rumsey and W. F. Schwedes (22 pp., 14 figs., *e.*). The paper presents data of a test of centrifugal motor driven pumps made at the Chapin Mine of the Oliver Iron Mining Co., where pumps are driven with electricity generated by water power. The article describes the general arrangement of the pumps, piping and electric control. The pumps were two 3-stage pumps working at an estimated dynamic head of 412 ft. against which they will have to operate when drawing 3000 gal. of water per minute, and two 6-stage pumps operating at the same capacity against an estimated dynamic head of 1000 ft. The pumps are of the multi-stage turbine type built in units of 3 stages each. The two single pumps each consist of one unit of 3-stages mounted on a common cast-iron bed plate with a 450 h.p. 1200 r.p.m. induction motor direct connected through a flexible coupling. The double pumps each consist of two 3-stage units driven by a similar induction motor of 1050 h.p. The motors are 3-phase, 60 cycle 2200 volt wound-secondary induction motors.

The article describes the method of taking the tests which does not materially differ from the usual practice, and gives complete data of the tests in the form of tables and curves. The purpose of the test was to determine for each pump with its motor, the head-capacity curves of pumps; over-all efficiency, wire to water, degree with which builders' guarantees were met, and the mechanical operation of the pumps and motors for vibration, thrust, heating and noise. As regards the wire to water efficiency at 3000 gal., the maximum obtained was 75 per cent. The pump bearings and oil for thrusts were water cooled, but no water was passed through the coils during the tests. The pumps ran very quietly on all loads and the 3-stage pumps with little vibration. In the 6-stage pumps some vibration occurred on account of the difficulty in holding the alignment of the long cast iron pieces on the steel flue plates. Absolute alignment of these pumps is of prime importance and their successful operation will depend more upon this than any other one factor.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Proceedings, vol. 30, no. 5, June 1914. Pittsburg.

Discussion on Measurement of the Velocity of Flowing Water (by Lewis F. Moody) and Pitot Tube Formulas —Facts and Fallacies (by Benjamin Feland Groat)
Air in Jet Condensers, C. L. W. Trinks

Discussion on Measurement of the Velocity of Flowing Water (by Lewis F. Moody) and Pitot Tube Formulas—Facts and Fallacies (by Benjamin Feland Groat) (90 pp., 22 fis., *gpt.*). For abstract of the original article, see *The Journal*, October, 1914, p. 201. Prof. Gardner S. Williams told about his experi-

ments with the Pitot tube. He had occasion to rate the same instruments in still water by dragging one attached to a car and also to test them in running water where the water passing the instrument was determined by measurement, and he has never been able to get the two ratings to agree. His opinion, therefore, is that in still water, the stationary Pitot tube does not get a rating that it would get by running past a measured quantity of water. Neither does he believe in the precision of current meter measurements. He had occasion to have a Haskell meter rating made in turbulent water. A quantity of water passing down the experimental canal at Cornell University was measured over a weir and then measured by a current meter in the hands of Professors Schoder and Turner, of the instructing staff of the University. Professor Turner had been in the employ of the United States Lake Survey and had participated in the stream gaging work on the St. Mary's River, according to the practice of the United States Lake Survey, which represents about the highest type of current meter work that has ever been produced. He testified under oath that the methods at Cornell were in entire harmony with those of the United States Lake Survey, and were of equal accuracy as far as manipulations were concerned. Nine gagings were made and the results showed that in the turbulent water which existed in the canal, although no more turbulent than is encountered frequently at gaging stations in a stream, the Haskell meter under-registered in the extreme case something over 9 per cent and in all cases over 3 per cent.

Bernoulli's theorem claims that the sum of the three heads must be constant in any stream line if friction be neglected. In experiments made by the author at Cornell University, he found that the pressure at the center of the pipe is less than at its wall. He took an instrument consisting of a flat plate having an orifice connected with a small tube and starting at the wall, he moved this plate across the stream, keeping it always parallel to the axis of the pipe. He found that at the wall, the pressures transmitted to the orifices coincided almost exactly with those indicated on the perforations in the periphery of the pipe in the same plane. As the orifices passed out to the center, the pressure appeared appreciably less.

Edward S. Cole told of his experiments made in the nineties and later, with the object of producing a practicable instrument for use in gaging the flow of water in the street mains of Terre Haute. It was found that there was a decided advantage in the use of the duplicate orifice, one bent upstream and the other downstream. A photo-recorder has been developed which has made the instrument more complete and efficient. The combined apparatus was given the name of Pitometer.

N. C. Grover of the United States Geological Survey discussed the general subject of measuring the velocities of water as actually done in the work of the Geological Survey. The stream gaging work of the Geological Survey has been conducted with a much higher degree of accuracy than would be warranted by the probable use of the resulting data. The work of the surveying engineer is very diversified and often done under difficult conditions, but is almost always required to give dependable results. The instrumental equipment for such work therefore must be simple, light and universally adaptable. The Fteley meter is perhaps the most accurate of current meters within the limits of its particular use. The Haskell meter is recognized as one of the best for work on large rivers. The Price meter is not very accurate when used in turbulent water, but under conditions that cause a vertical motion of the meter, or when used under proper conditions, it will give results within reasonable limits of accuracy. The Survey, several years ago, employed an expert mechanician in an unsuccessful attempt to convert the screw type of current meter into a form for universal use, but later had to abandon it owing to the lack of available funds.

William Kent stated that he has used a Pitot tube as a check upon other methods of measuring the discharge of a pump at high pressure, and found its readings to give measurements which agree within one per cent of those obtained by a calibrated nozzle and pressure gage and those obtained by a weir, using the Francis formula.

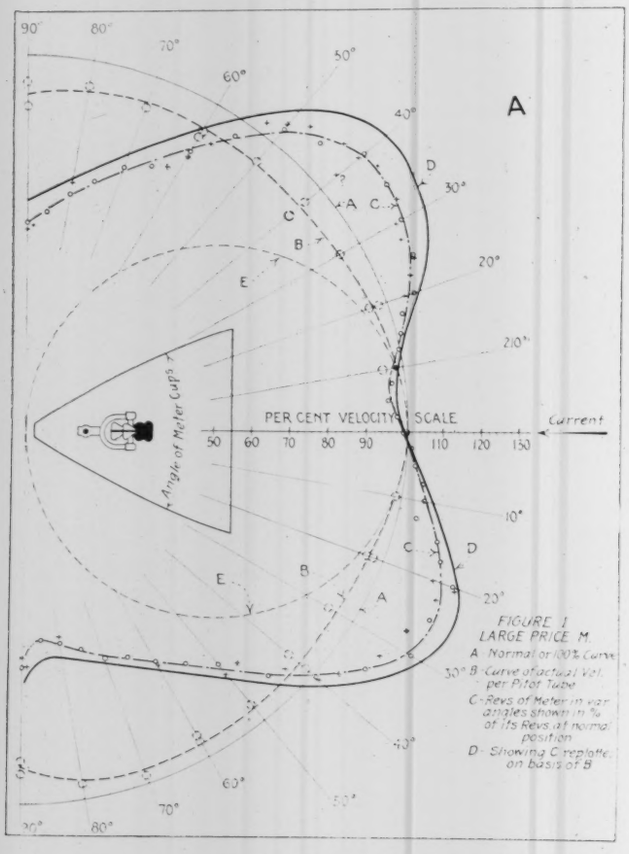
Professor Charles M. Allen stated that he had made several hundred experiments with Pitot tubes of various types to determine the coefficients of the instruments for still water and moving water ratings. It was found that the ratings were constant, but in all cases the coefficients varied with the velocity. In still water in every case, they were higher than in moving water readings to the extent of from 3 to 5 per cent. Pitot tubes should be rated in moving water at the same velocities at which they are to be used.

Morris Knowles related some of the early history of the velocity-of-water measurements. In experiments conducted upon jets issuing from standard orifices, it was very evident that a marked retardation of velocity in the jet occurred about the outer edge. If Bernoulli's theorem were applied to two points, one at the center of the jet and the other at the outer edge in the same plane, the decrease of the velocity head at the outer edge would necessitate an increase in the pressure head to balance the greater velocity head at the center, but if the outer edge of the jet were under greater pressure than the center, this pressure would cause the jet to lose its form, which appears to show that the Bernoulli theorem is not applicable to two such points.

A. H. Brown and F. Nagler have given a preliminary report of experimental work performed with a view of determining the possible causes of the over-registering of the cup type of current meter. It fully describes the method of tests and shows the arrangement of apparatus for testing current meters. It was found that if the meter be placed at a slight angle either above or below a horizontal, that the revolutions increased very materially. At 90 deg. positions above or below horizontal, it showed contrary to expectations, approximately one-half the number of revolutions that it registered in its normal presentation to the flow and in the same direction. The curve shown in Fig. 6 indicates also the shifting of the whole curve occasioned by the difficulty experienced in fixing the normal position. Under constant velocity of water, this particular meter will over-register as high as 25 per cent when placed at an angle to the normal direction of flow vertically. This effect, however, is slight up to the 45 deg. limit and is merely to reduce the number of revolutions, the reduction increasing with the angle.

On the curve of Fig. A, the circle *A* is drawn to show the theoretical performance of the cup type of meter when placed at various horizontal angles. Under such conditions, neglecting the effect of the frame, it may be assumed that a constant velocity will be registered regardless of the angularity of the meter. This circle also shows the performance of any type of meter so supported that it is free to

swing in any direction. The circle E, drawn in on one-half the diameter of A indicates, by the length of the various vectors intercepted, the true components of velocity and represents the ideal meter performance. The dotted curve C is plotted on the actual test readings of the meter under test and indicates along the 25 and 35 deg. lines the approximate maximum error. These lines lie at an average angle of 30 deg. with the horizontal, which corresponds to the 60 deg. angle (approximate) of the bucket itself. This double curve C is plotted in on the basis of percentage of curve A. The error would be greatly emphasized if it were plotted in on the basis of circle B, which shows the true resolved components desired.



The Pitot tube readings are shown along curve B, which is also plotted in percentage of A. The curve D is replotted in percentage of A by basing C on B rather than on A.

Contrary to general ideas of the performance of the cup type of meter, it appears that in this case the over-registering is due to the fact of angularity of flow in a vertical plane rather than to that in a horizontal plane. The angularity of flow in a vertical direction speeds up the meter to a considerable amount over the known error due to horizontal angularity of the flow. It appears, therefore, that the large Price meter should only be used when it is swinging free in all directions. The next series of tests were made with a small Price single point cup type of meter as made by Gurley. The data of these tests are given in a curve similar to the above. When rigidly supported, the modern small Price cup type of meter was found to be remarkably accurate in giving resultant components of velocity when subjected to flow that was distributed uniformly in all directions, but preponderance of angularity in any one direction, either horizontally or vertically, caused over-registering or under-registering. In turbine work where the measuring section is selected upstream from the turbine adjacent to the entrance of the channel, the meter is apt to over-register.

The general conclusions of the speakers are that even the best cup type of meter should preferably be used swinging and never rigidly supported unless it is known that disturbances are uniformly distributed in all directions, a thing which can hardly be accomplished in practical work. The ideal meter is one which being rigidly supported in disturbed water, will register only two components of velocity when subject to flow from any direction. This means that it must have identical, vertical and horizontal characteristic curves and to do this, the axis of rotation must coincide with the normal direction of flow which at once limits the choice to the screw type of meter, the design of the head of which shall be such as to give the desired true components.

Herman Bacharach told of his experiments in recording the velocity of flow with a Pitot tube. He gives a table of velocities (Fig. B), showing the results of tests made with various shaped tubes where little variation has been evident with the different types of tubes, the greatest difference being shown by the short tube. He also describes an instrument for indicating or recording dynamic pressures. Mr. W. M. White discusses the diversity of opinions with regard to the correct formula for h in the pitot tube measurements. He has devised a special apparatus for determining, experimentally, the true relation between the head and velocity. He found that the formula $h = \frac{v^2}{2g}$ is correct for the point of the Pitot tube, and then devised a rather simple apparatus for obtaining the true pressure in the water at or near the point of the Pitot tube in order to find the increase of pressure in the impact pipe caused by the velocity striking the Pitot tube point over the static pressure in the pipe. Here again he found the same formula to hold good. In order to

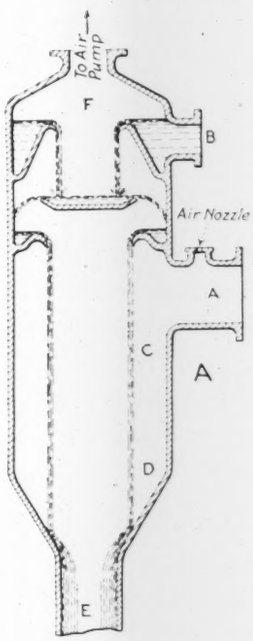
B

AIR VELOCITY IN METER - SEC.	SHORT TUBE	MEDIUM TUBE	POINTED TUBE	LONG TUBE WITH FUNNEL	TUBE WITH DISC
	In Millimeter - Water Gauge				
2.29	0.342	0.342	0.342	0.342	0.342
2.76	0.460	0.490	0.504	0.494	0.507
3.23	0.660	0.690	0.714	0.680	0.686
3.68	0.860	0.910	0.920	0.910	0.890
4.13	1.070	1.130	1.150	1.120	1.123
4.57	1.290	1.350	1.370	1.370	1.379
4.94	1.530	1.570	1.600	1.590	1.615
5.27	1.740	1.810	1.810	1.810	1.838
5.65	1.980	2.050	2.060	2.080	2.118
6.20	2.350	2.450	2.410	2.420	2.540
6.64	2.650	2.770	2.770	2.770	2.780
6.97	3.000	3.150	3.150	3.150	3.210

Fig. 6 Measurement of Flow of Water by Current Meters and Pitot Tube

test the statement of Gardner S. Williams, that the pressure in the water measured along the diameter of the pipe is not the same, but varies in accordance with Bernoulli's law, he designed a special apparatus in which provision was made to discharge a jet of water at various velocities as high as 30 ft. per second, through a 3¾ in. disc nozzle. The object of the experiment was to determine the pressure within the jet of water at high velocity and more particularly to establish the fact as to whether the velocity along the shortened rod, as a piezometer holds, affected the pressure reading at that point. While some of the curves obtained would seem to indicate a slight difference in pressure between the center of the jet and its outer edges, the author comes to the conclusion that it may be expected with reasonable certainty that the velocity is the same across the jet. From other curves, it was found that the pressure in the water dropped to atmospheric just at the edge of the nozzle. The only explanation that the author can give for it is that it is due to surface tension on the jet. It appears, therefore, that there is no drop in pressure due to high velocities.

The closure of Prof. Lewis F. Moody, while of great interest, is too extensive for abstracting.



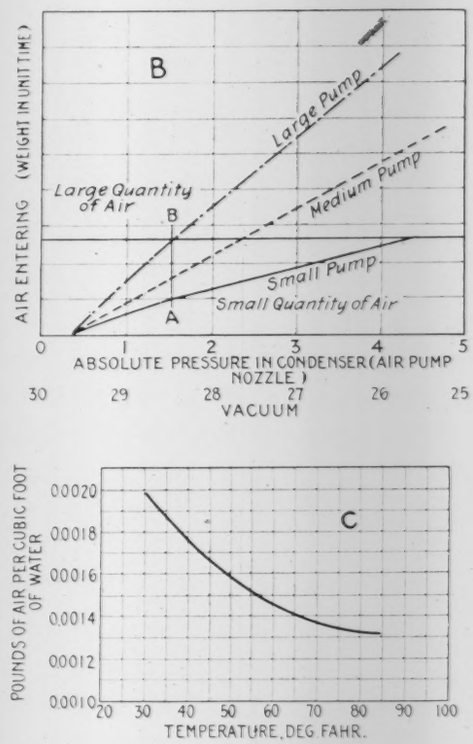


Fig. 7 Air in Jet Condensers

Air in Jet Condensers, C. L. W. Trinks (45 pp., 20 fig., *et*). The article deals mainly with the influence of air on the performance of jet condensers. It shows an experimental jet condenser erected at the Carnegie Institute of Technology especially for this test. A constant rate of water flow and a constant rate of steam flow were maintained; the speed of a reciprocating air pump which took air out of the cool top of the condenser was also maintained constant, but a variable quantity of air was admitted with the steam through orifices. Although the weight of air admitted through the largest nozzle did not exceed 1.4 per cent of the weight of steam entering at the same time, the vacuum dropped from 28.5 to 23.2 inches, which means the difference between very good and very poor vacuum. The temperature distribution in the condenser as shown by the diagram of Fig. 7, explains how even a very small quantity of air spoils the vacuum. The temperatures were measured at points *A*, *B*, *C*, *D*, *E* and *F*. If the condensation were most efficient, the temperatures at *A* and *E* would be the same, as was found to be the case in a test with no air in the steam. As more and more air was admitted, however, the temperature at *E* (tail pipe) did not change, but that at *D*, *C* and *A* changed, rising slightly at *D*, more at *C* and the most at *A*. The temperature at *E* remained constant because, although the steam admitted was apparently hotter, it really, in spite of its higher temperature, contained no more heat because it contained more water. In a condenser which takes steam from an engine or turbine, however, the tail water temperature would rise with the addition of air to the steam on account of the increase of steam consumption for a given load on the prime mover caused by the dropping of the vacuum. Neglecting the normal slight pressure drop between the steam entrance *A* and the air pump nozzle, it may be said that the pressure in the condenser is constant everywhere, and further, the partial air pressure in the condenser increases rapidly toward the air pump nozzle.

As regards the quantitative fact of the presence of air in the condenser, the author points out that the air pressure at the air pump nozzle of the condenser adjusts itself automatically so that equilibrium is established between the air entering and the air removed, the latter being accomplished not only by the air pump, but also by the tail water. The capacity of an air pump in pounds of air in unit time is expressed by its characteristic or characteristics which can be found only by actual tests. If, however, the builders of air pumps know these characteristics, they do not publish them which makes the performance of condensers entirely uncertain, as the condenser owner has no means of knowing

how much air leaks in or how much he pumps out. Further, all the characteristics of air pumps which have been published are based on the pumping of dry air which may be entirely different from the characteristics of air and vapor mixtures.

Fig. B shows the influence of air pump characteristics on vacuum. It assumes the knowledge of the characteristics of the air pump on a given condenser as well as the knowledge of the temperature at the air pump nozzle and absence of appreciable pressure drop between the air pump and the air pump nozzle in the condenser. The characteristics of three similar pumps of different sizes are indicated as well as two rates of inflow of air. It is evident that the same vacuum may be maintained in spite of different rates of air inflow if corresponding air pump capacities are employed. In connection with the use of the characteristics for actual condensers there are two difficulties; in parallel flow condensers, the lack of definite knowledge of the temperature at the air pump nozzle, and in countercurrent condensers, the possibility of pressure at the air pump nozzle of the condenser being different from the pressure in the condensing space proper. The author comes to the conclusion that the temperature of the air and vapor mixture depends upon the rate of air inflow and air removal while the rate of air removal depends upon the temperature of the air and vapor mixture. He discusses the influence of air pump capacity in countercurrent condensers at considerable length.

As regards the weight of air in a condenser under normal conditions, the injection water carries up to 2 per cent of atmospheric air by volume or approximately $^1/_{400}$ per cent by weight, or, further, $^1/_8$ per cent of the weight of the steam; some of this air stays in the water even at the low pressure of the condenser. The weight of air coming in with the steam from the boiler feed water is usually negligible, but air enters the condenser with the steam on account of leaks. This depends on the average air pump capacity which may range from 2 to 4 times the quantity of air entering with the water. If more enters, the vacuum must drop. Tests of condensers show reasonable uniformity in the effects of air leaks. The author gives a curve derived from a test on a Mesta barometric condenser and a Westinghouse Le Blanc condenser. With 1 per cent of air by weight in the exhaust steam, the vacuum is exceedingly poor. The author states, however, that there is no reason why that should be so, provided the air pump is made large enough and there is a sufficiently free passage in the condenser for the air. The point is only where to draw the line and whether to build a condenser and pump for an $^1/_8$ per cent leakage or for 1 per cent or more.

This question leads to a good deal of quarreling between the condenser builders and the condenser owners, and could be easily avoided by devising an instrument for the correct measuring of the quantity of air in exhaust steam. The author briefly describes the principle upon which he worked in order to devise an air detector. The device is said to be really a reliable piece of laboratory apparatus but a very poor instrument for power plant use.

He proceeds to discuss the influence of subdivision of injection water. Observation through the glass windows of the experimental condenser at the Carnegie Institute of Technology revealed the fact that the steam blew the sheets and jets of water literally to atoms, producing a vast condensing surface in a small space. The following fact proves further that the condensation was completed in a very small space; the tail water level was gradually raised in the condenser until it touched the steam pipe and no change in the vacuum could be noticed, although the steam flow and water flow were quite heavy compared with the size of the vessel.

In the discussion which followed, Karl Nibecker stated that he recently conducted tests on a condenser where the drop in the vacuum from the air pump to the steam inlet nozzle was 0.66 in. of mercury. He believes that this excessive drop was due entirely to poorly designed weirs and insufficient condensing area at the base of the vessel. In a condenser with the weirs properly designed, the drop in vacuum has been found to be less than $^1/_2$ in. He suggested further that it would be good practice to make the air pump capacity 8 to 10 times the amount of air brought in by the water and usually operate the pump at very slow speeds. When air leaks are developed during the operation, the pump speed can be increased and a reasonable vacuum maintained until such time as the pump can be taken off conveniently for repairs. He also described a type of air detector which is expected to give good satisfaction.

W. E. Snyder stated that after a wide condenser experience, he finds that the only feature which gives the most trouble to condenser men is the lack of air pump capacity due to insufficient attention to operating conditions by the companies designing condensers. Another difficulty in connection with the operation of condensers which is being gradually eliminated, however, is driving both the air and water pumps by means of one prime mover, making it impossible to vary one independent of the other. While the speaker agreed with the general statement that some leakage of air into the exhaust system under vacuum is bound to occur, he suggested several general rules for keeping this leakage down to minimum.

J. B. Shatzer describes a multi-jet condenser based on the principle of subdividing the condensing water and passing it through the condenser at a high velocity. No complete tests on this type of condenser have yet been made, the only point on which data have been obtained being the water ratio of the condenser and the amount of air handled without admitting steam. The water ratios run on an average higher than is required for the ordinary jet condenser. In most cases, the difference in the temperature between the theoretical vacuum and the tail water is about 15 deg. or higher than that obtained by other condensers. This is not considered disadvantageous by the builders, because the work ordinarily done by an air pump in a condenser system is in this case taken care of by the extra water passing through the condenser, this being resorted to in the belief that it is more economical to remove air by means of a highly efficient water pump than by an air pump of low efficiency. A set of curves is given to show the air handling capacity of a jet condenser, showing its increase with the pressure maintained on the condensing water, and also showing that with the pressure of 15 lb. in the water head, it is possible to admit 0.7 lb. of air per minute and still maintain a vacuum of about 20 in.

R. M. Rush told of his experiments with carbon packing and steam sealed glands on turbines and engines. They had to deal with an exhaust steam turbine operating in connection with an engine and governed entirely by the engine. It was found that at partial load the vacuum would go back into the engine cylinder. Under these conditions, the air

leaks around the stuffing boxes of the engine would be so great that the vacuum would be interfered with in the condenser, but it would be possible to prevent the leakage of air along the engine piston rod by means of carbon packing rings split in three parts and held together with a spring. The author believes that low vacuum which is so common around steel mills might be bettered by the introduction of carbon steam-sealed packing on reciprocating units.

N. Owitz objected to having an air pump on a condenser larger than is really needed for the duty required on account of the additional expense. He described the principles of condensation in a jet condenser as well as the countercurrent type of such condenser, and gave the results of tests of the countercurrent jet condenser shown in a figure in the text. In that specific jet condenser, the cooling water can be discharged at exactly the temperature of the exhaust steam or at an efficiency of 100 per cent. With increased consumption of the cooling water in an ordinary jet condenser, a larger air pump and an increased power consumption by that pump would follow from an increased amount of air brought into the condenser by the cooling water. The countercurrent type of construction of a jet condenser and the consequent cooling of non-condensable gases passing through the air pump at a low temperature result in a minimum load on the air pump required to maintain a given vacuum in the condenser. The speaker pointed out that air can be introduced with circulating water in a suspended or globular state where the water supplied to the condenser has been allowed to become intimately mixed with the atmosphere.

In the case of still water, the amount of air in each cubic foot of water may be said to vary about as shown in Fig. C. While, however, the amount of air by weight dissolved in each cubic foot of water seems to be very small, the actual volume of air becomes very large because of the low pressure exhaust. Professor Trinks, in connection with the latter remarks, called attention to the fact that in a countercurrent type of condenser the pressures at the top and at the bottom are determined by different considerations. With a large, fast running air pump, small water flow and little air leakage, steam must break into the top of the condenser and spoil the efficiency of the air pump.

FRANKLIN INSTITUTE

Journal, vol. 178, no. 3, September 1914, Philadelphia, Pa.
Stability of Aeroplanes, Orville Wright (abstracted)
The Screw Propeller, W. F. Durand

Stability of Aeroplanes, Orville Wright (10 pp., *g.*). The article is an address made by Mr. Orville Wright when he received the Institute's Elliott Cresson medal. It presents a general discussion on the question of stability of aeroplanes and describes the development of the stabilizing and the conditions of loss of equilibrium. He concludes by describing the various methods of automatic stabilization.

IRON AND STEEL INSTITUTE

Advance copy, autumn section 1914.

The Decarburization of Steels in the Salt Baths Used for Heating Prior to Hardening, A. M. Portevin (abstracted)
Utilization of Heat Contained in Slag, W. L. Johnson (abstracted)

The Decarburization of Steels in the Salt Baths Used for Heating Prior to Hardening, A. M. Portevin. The article discusses the decarburization of steel when treated in baths of molten alkaline salts. Such baths are becoming more and more usual for the heating of steel bars prior to hardening. They allow much more rapid heating of the small parts and of gradually adjusting the temperatures of heating in addition to eliminating or at least considerably reducing the superficial oxidation. They involve, however, a little realized danger of producing spot or superficial decarburization, especially where the heating is prolonged. The author has carried out a series of experiments with the object of investigating this decarburization. He maintained for various periods in molten potassium chloride at a temperature of 1000 deg. cent., samples of a hypereutectic steel containing 1.46 per cent of carbon. It was found that with an increase in the length of time the samples remained in the bath, there was an increased decarburization marked both by the increase in the depth of decarburized layer and by the lowering in carbon percentage of the surfaces, falling as low as 0.2 per cent. The decarburization is most effective after quenching and is better revealed by the Shore sclerometer than by the Brinell test because the former applies only to a small depth. At 900 deg. cent. the decarburization is not so deep, but almost as great so far as the superficial lowering of the carbon percentage is concerned.

Experiments with the same steel in the salt bath described by Brayshaw for use in hardening furnaces (Potassium chloride 0.56; sodium chloride 0.39; soda 0.5; potassium ferro-cyanide 0.2) showed that the degree of decarburization is nearly the same as when pure sodium chloride was used and the influence of the small amounts of ferro-cyanide added with the object of counteracting the decarburization, did not appear very efficacious. The employment of mixtures of cyanide and cyanate of potassium has enabled the author to establish equilibria of carburization between steels and the bath so as to obtain simultaneously in the same bath the decarburization of hard steels and the carburization of dead-soft steels. The two phenomena appear then to tend toward a common limit which would be the carbon concentration of the steel which remains in equilibrium at 900 deg. cent. in the chloro-cyanide bath. This limit appears to be independent of the quantity of potassium cyanide present in the bath. It has been noted that very frequently when this bath contains cyanide of potassium and likewise when it contains ferro-cyanide of potassium, there appears subjacent to the carburization layers, needles of appearance similar to those described by Braune in his researches on the influence of nitrogen on iron and steel. The article contains tables of data obtained by these tests.

Utilization of Heat Contained in Slags, Walter L. Johnson. The article contains a description of the method for the utilization of heat contained in slags. It describes the apparatus used for producing the steam and the calandria, in this case the Kestner single-effect climbing film evaporator. At first it was intended to use the steam produced in an exhaust steam turbine, and after numerous experiments on blades of different metal, it was found that duralumin was affected very slightly so that a 50 kw. turbine with blades of this material was experimented with. The steam produced from ordinary gray Cleveland (England) slag contains about 0.5 per cent by volume of non-condensable gases: sulphureted hydrogen and nitrogen. They were absorbed by washing the gases with milk of lime to

absorb the sulphureted hydrogen and then passing the remainder through a tube containing calcined Cleveland ironstone heated to a temperature of about 750 deg. cent., the nitrogen being taken care of by the air pump.

When at the end of two months the turbine was opened up, the openings were found to be partly blocked up with fine sulphur which had caused some wear of the blades. After this the direct method was abandoned and a water heater or heat exchanger introduced between the turbine and the primary generator. With steam from slag at 100 deg. cent. and the temperature in the calandria 91 deg., the mean of 22 experiments gave 173 gal. of water evaporated per hour and the average steam per hour condensed in the calandria was 190.2 gal. Experiments were also made to determine the amount of available steam from the slag by condensing and measuring it. The mean of 7 experiments gave 1017 lb. per ton of slag, but after deduction, 855 lb. of clean steam available for the turbine. Since the modern exhaust steam turbine with full load on and a vacuum of 28½ in. can be guaranteed under the above conditions to use not more than about 27 lb. per h.p., this gives 31.6 h.p. per hour per ton of slag per hour.

As regards the cost, the author states that the difference in practice at different works makes it impossible to give the cost of running such a plant. Apart from handling the slag, the cost of the electric installation is the same as in the ordinary exhaust steam turbine plant of a similar size, and the attendant can regulate the water in the calandria. But there is about 2 per cent more power required for the greater amount of condensing water per h.p., and where the slag is already being granulated, there is the extra up-keep of the second elevator. One man per furnace should be able to attend to the primary generator and running in the slag, the remainder being mechanical.

SOCIETY OF CHEMICAL INDUSTRY (BRITISH)

Power Costs in Various Works, T. Rolland Wollaston. The present abstract is taken from the *Iron and Coal Trades Review*, as the library of the Engineering Societies has not yet received the proceedings of the Manchester section of the Society of Chemical Industry. It is devoted to a comparison between various methods of steam generation for power purposes with other thermal prime movers. The author does not believe that the ordinary boiler furnace provides a satisfactory means of burning coal to advantage. The same chemical reactions are supposed to take place where the coal is burned in a bed 9 in. deep on a boiler grate or 6 ft. deep in a gas producer. With the gas producer, however, the gas is generated and burned under conditions closely approximating theoretical accuracy. In the boiler furnace, on the other hand, even in the best practice, a very large amount of excess air is used which vitiates the results, while the maintenance of the correct conditions for combustion in a thin bed over an area of say 20 sq. ft. is a matter of impossibility, even with the most perfect mechanical stoking devices. At the same time, in the boiler furnaces the radiant heat of combustion is usefully employed, but dissipated in the producer.

The producer type of furnace attachable to boilers of the Lancashire and other types in which the air for combustion is highly preheated through the agency of the radiant heat of combustion, is said to have been experimented with with some success. Hitherto, the firing of boilers by producer gas has only proved a paying proposition when the by-products could be extracted from the gas previous to its combustion, and even then only on a large scale. It may be expected, however, that recovery gas producers in conjunction with special boilers will enable the plant as a whole to work at approximately the same efficiency as the normal hand-fired boiler, the resultant by-product paying for a large part of the fuel costs, and in certain cases even showing a profit.

The author proceeds to give data of cost of operation of various types of prime movers, such as steam turbines, the same plant with high duty gas fired boilers, a 2000 h.p. recovery gas plant with gas engines, 2000 h.p. of Diesel engines and a similar amount of power from peat gas recovery plant of the Mond system. The most surprising result is in the last one, for which the data given by the author are reproduced. Not only is the power free of cost, but there is an actual profit of 21 per cent on the capital outlay. The capital cost of the plant, however, is extremely high—higher than in any other type of prime mover:

TABLE 1 PEAT GAS RECOVERY PLANT, MOND SYSTEM WITH 2,000 H.P. OF GAS ENGINES

Capital Costs		
2,000 h.p. peat recovery plant		£24,000
2,000 h.p. of gas engines at £6		12,000
Foundation and buildings and auxiliaries		6,000
		£42,000
Running Cost		
Dr. to 33,000 tons of peat at 5s		£8,250
" 2,140 tons of acid at 33s		3,530
" Oil and stores, say		700
" Bags and packing sulphate		713
" Labour, 27 men at £70		1,890
" Maintenance at 2 per cent		840
" Interest and depreciation, 10 per cent		4,200
		£20,123
Cr. by 2,140 tons of sulphate at £12 10s	£26,750	
" 2,140 tons of tar at 20s	2,140	
		28,890
Credit balance		£8,767
Cost per h.p. hour		nil.
Cost per h.p. year		nil.
Equivalent cost per unit		nil.

With a clear profit of 21 per cent on capital outlay.

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

While in general, foreign engineering periodicals are published, at least in sections of Europe not directly affected by the war without much interruption, the events begin to affect their size and wealth of material, some of the papers having cut down the numbers of the issues, and others the number of pages. As is mentioned in one of the articles abstracted in this issue, some projected investigations have been stopped for lack of funds owing to the general tendency to economize on everything that does not bear directly on the war. Another regrettable feature of the present situation is the long lists of "dead for their country" published by some of the European engineering societies and representing a grievous waste of the best constructive forces of their respective countries.

THIS MONTH'S ARTICLES.

The first article treats of the proper dimensioning of heating surfaces in heating installations where steam, either exhaust or live is used, and among other things, describes the arrangement used when the waste heat of internal combustion engines is utilized. The article is not yet finished. It may be explained here, by the way, that contrary to the usual practice of the Engineering Survey, several unfinished articles have been abstracted in this issue. This is done because foreign papers now come irregularly, several issues at one time, and that there may be a long delay when none are received. Under these conditions to wait until the entire text of the original article is at hand would be contrary to the policy of the Survey to be as much up to date in its information as possible, and so the plan is to give abstracts of such unfinished articles as present in the part available, sufficient data to make them of immediate interest.

In the section Internal Combustion Engineering is given a description of two new types of gas producers, one of which is especially adapted to handle vegetable refuse and particularly seaweed, in the latter case with the recovery of potash and potassium carbonate.

In the section Steam Engineering are described straight-flow rolling mill engines, and interesting data are given on the jet condenser connected with it. The data of tests with recording load meters on steam engines are of particular interest in these days of vigorous effort to secure maximum efficiency of apparatus used. Besides, as shown in the article, the use of the recording indicator enables one sometimes to locate trouble of an otherwise elusive character. In Schulz's article on temperature measurements in evaporation tests is discussed the still mooted question (in Germany) as to what is the entrance to the economizer, and how thermometers in evaporation tests should be placed. Valuable data on the distribution of temperature in the economizer are cited. Pradel's description of the Pellegrino grate forms part of his usual quarterly account of progress made in the field of boiler firing, the closing part of which will be abstracted in an early issue of *The Journal*.

In the section Thermodynamics are reported two important investigations, Hornborn and Jakob's on the specific heat of air at 60 deg. cent. and various pressures, up to 200 atmospheres; and of Stodola on the phenomenon of undercooling of steam flowing out from nozzles.

In the paper presented by F. G. Cutler before the American Iron and Steel Institute are described some of the improvements in power generation made at the Ensley plant of the Tennessee Coal, Iron and Railroad Company. Their great importance and extent can be judged from the author's statement that "the saving in coal with the present equipment and methods of operating over the former practice is estimated to be at the rate of 200,000 tons per annum." R. L. Daugherty, in a paper before the American Society of Civil Engineers, presents data on the performance of a reaction turbine made at Cornell University with a greater thoroughness than is usually the case with commercial tests.

Two papers are reported from the Journal of the American Society of Marine Draftsmen, a new publication which we take this opportunity to welcome.

Temperature Cycles in Heat Engines, by Professor F. G. Coker and W. A. Scoble, and Seventh Report of the Explosion Committee, are the titles of two papers before the Australian meeting of the British Association which have already attracted considerable attention in the European scientific and technical press. The second of these papers describes, among other things, methods of measuring the temperature in the cylinder of an explosion engine so as to determine it at various parts of the cycle.

The locomotive arch brick is the topic discussed by G. Wagstaff before the Central Railway Club. It contains statistical data concerning engines equipped with fire brick arches in this country and Canada.

A method of determining the internal stresses in heat treated axles, and a discussion of the influence of quenching by horizontal or vertical immersion form the subject of a highly interesting investigation, by H. V. Wille, published in the Journal of the Franklin Institute.

From the recent publication of the Institution of Mechanical Engineers are abstracted the report of the Refrigeration Research Committee, and the paper of Dr. W. E. Fisher on the Discharge of Steam through Nozzles. A paper on the Theory of Flow of Gases through Nozzles, by J. G. Stewart, had to be left out for an early issue on account of lack of space.

Finally, from the Quarterly of the School of Mines has been taken an account of the recent tests on the physical properties of steel and cast iron bars broken at various temperatures.

Heating

UTILIZATION OF EXHAUST HEAT OF ENGINES FOR PURPOSES OF HEATING WITH PARTICULAR REGARD TO THE DIMENSIONS OF HEATING SURFACES (*Über die Verwendung der Maschinenabwärme für Heizzwecke unter besonderer Berücksichtigung der Heizflächenbemessung*, Dr. Wilhelm Deinlein. *Zeits. des Bayerischen Revisions-Vereins*, vol. 18, no. 17, pp. 163, September 15, 1914, serial article, not finished. *dp*). There is quite a large amount of information in existence on the utilization of waste heat of prime movers for

the purpose of room heating and water heating, but in most of the articles which have appeared so far, insufficient information is given with respect to the auxiliary apparatus used in such installations and especially with respect to dimensions of the parts. The present article takes up these features with special regard to room heating, hot water production and feed water preheating. It gives a general account of the systems of heating by exhaust steam, both exhaust in the true sense of the word and live steam used for heating purposes before its admission to the prime mover which the author calls in this case "incoming" steam. The author gives several diagrams of connections for heating by low pressure steam from an engine exhausting into the atmosphere, vacuum heating with the condensing steam engine, hot water heating from an internal combustion engine, the latter shown in Fig. 1. From condensing steam engines, water is obtained with temperatures of from 40 to 80 deg. cent. (104 to 176 deg. fahr.), according to the degree of vacuum available. With internal combustion engines (according to their size) water temperatures up to 70 deg. cent. can be obtained, but in the case of larger engines, especially gas engines, the temperature has to be maintained considerably below 70 deg. cent. (158 deg. fahr.). The author knows of no case where water of condensation or cooling water is used for heating purposes with supplementary heating. The possibility of such an arrangement is recognized in industrial concerns only for the purpose of heating shops and offices and the general objection to it is the low temperature of heating and the necessity of reserve installations, which involve a large investment.

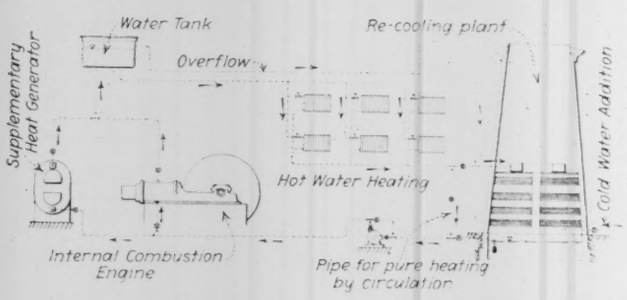


Fig. 1 Heating Installation Using Waste Heat from Internal Combustion Engine

Internal-Combustion Engineering

Modern Progress in the Theory and Practice of Gas Producers (*Die neuern Fortschritte in Theorie und Praxix der Generatorgaserzeugung*, J. Gwosdz. *Glückauf*, vol. 50, no. 41, October 10, 1914, serial article, not finished. *d*). The article describes the progress made during the last few years in the design of gas producers. Among the types described, of particular interest, are those of Ragot and Pierre-Hervotte (French, though patented in Germany) and the German Pintsch generator, of which a new type is shown in the article. The former of the two is designed mainly to burn vegetable refuse and other cheap fuels. It has two zones of combustion, *a* and *b* (Figs. 2 A and B), located one above the other and composed of superimposed truncated cones. The downward shaft is closed by a wire screen pipe *c* and grate *d*, which is designed partly as a valve. The admission of air and steam to the upper and lower admission pipes, staggered with regard to one another, is effected through the circular pipe *e* and admission branch pipe *f*. The peculiar feature of the design is the use of the undershaft section *g* as a water container, into which the wire screen cylinder *c* and grate *d* are dropped; the gas is forced therefore to pass through the water of the container *g* before it can reach the chamber *h* and from it the gas eduction pipes. In this way, before entering into the piping, the gas is freed from impurities and such undesirable constituents as wood vinegar. The bubbling of the gas through the water container *g* helps also to break up the ashes on the grate *d* and to prevent the clogging of the interspaces between the grate bars. When plants are used as a fuel, this action of the water on the ashes helps also to recover such

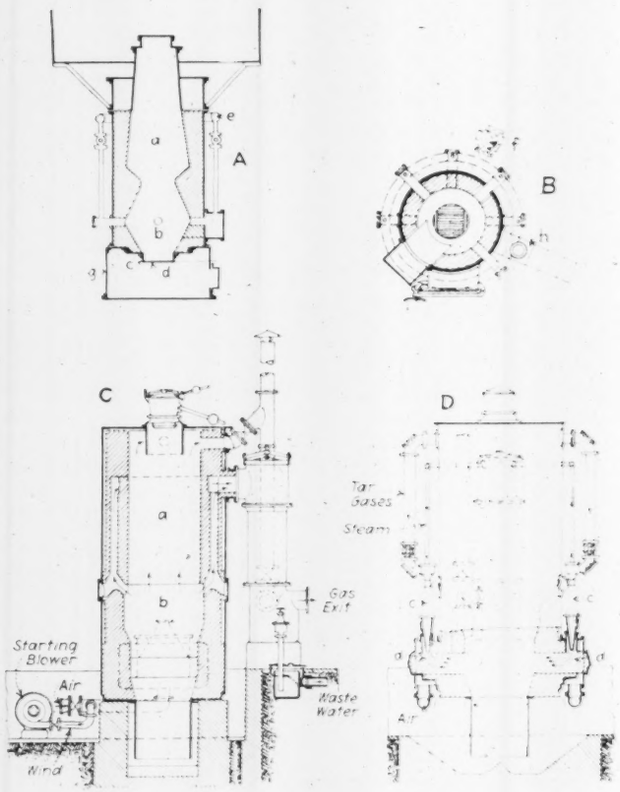


Fig. 2 New Types of Gas Producers

solids as potash and sodium carbonate. This type of producer is therefore particularly adapted for burning seaweeds along the coast region.

The development of the new Pintsch producer was based on the idea that a more effective tar separation would be obtained if the gas were freed from soot. In the producer shown in Figs. C and D, the fuel is completely distilled in the gasification shaft *a*, and taken out as coke from the gasification shaft *e*. The producer gas forms in the latter shaft for the most part closely around the gasification shaft through passages made in the brick setting and reaches the point of consumption, while a smaller part of it is taken in through suction by means of the steam jet blower *c*, through the gasification chamber and, together with the gases of distillation, reaches the hearth *d*, where the gases are mixed with the air taken in by the motor or suction

blower and are completely burned in a free flame. The products of combustion are then again for the most part converted into combustible gases in the hot zone of combustion. As shown in the figure, the contents of the shaft repose over a tank filled with water, which permits the ashes to be removed conveniently without producing any disturbance in operation. The lower heating value of the gases produced is approximately 950 to 1000 WE. (1800 B.t.u. per pound), or approximately equal to the heating value of blast furnace gas, but considerably below that of the ordinary producer gas. The average composition in a 150 h.p. plant has been found to be CO_2, 8.6 per cent, CO, 18.3 per cent, H, 14 per cent and CH_4, 0.6 per cent. Thermal efficiency is from 60 to 70 per cent and the fuel combustion 0.48 to 0.59 kg. per effective h.p.

Steam Engineering

Concerning Measurement of Temperature in Evaporation Tests (*Über Temperaturmessungen bei Verdampfungsversuchen*, M. R. Schulz, *Zeits. für das gesamte Turbinenwesen*, vol. 11, no. 28, p. 419, October 10, 1914, 3 pp., 1 fig. *ep*).

The article discusses the method of taking temperature readings in evaporation tests. The author finds that in a number of tests on boilers, superheaters and economizers, the data obtained did not quite agree with the actual conditions. The author believes that the fault lies in the fact that the instruments for measuring the temperatures are not placed in the proper positions and proper parts of the gas currents. He found that in recent tests on economizers the economizer appeared, according to the test data, to have taken up more heat than was available for its use, which, of course, would be due only to improper measurements.

In Germany, guarantees of economizer performances usually state that the guaranteed performance is to be based upon the temperature at the entrance to the economizer and the author has noticed that this essential condition is not always satisfied. According to the belief of the author, the entrance to the economizer can be understood only as the place where the gases enter the economizer, and an economizer is understood as a system of piping built into a brick structure and provided with an entrance chamber and exhaust chamber. If one mixes the flue gas and air in the entrance chamber of the economizer and calls it the entrance to the economizer, only false results, according to the statement of the author, can be obtained.

To prove this, the author placed absolutely similar thermometers at the same depths of immersion. The first three of them he placed in the main flue at the entrance of the gases into the economizers at the places indicated in Fig. 3 as *a*, *b* and *c*, and then three more in the entrance chamber at the places marked *d*, *e* and *f*. The first three thermometers were placed in their three measuring holes vertically and the other three thermometers horizontally, somewhat inclined, while a seventh thermometer was placed into a hole in the cover of the economizer casing *g* vertically. At the same time, in the flue passages of the four boilers then in operation, measurements of the flue gases were made, at a distance of about 1 m. from the boiler, so that the instrument should not be affected by the heat radiated by the boiler setting.

The author asserts that it is wrong to believe that the flue gases can be materially cooled down in the main flue during the passage of from 30 to 50 m. (98 to 164 ft.) long. In the present case, the cooling amounted at most to 10 deg., although the flue was over 30 m. long. If cooling is actually established in the main flue, it is due to the fact that the valves are so lacking in tightness that large amounts of air are permitted to enter, or possibly the valves are open on other boilers which are connected with the smokestack but are not in operation (perhaps because they were being cleaned). It is of great importance, therefore, during the test, to allow no cold air to enter into the main flue, and it is best to have the valves on the boilers which are not in operation covered with clay.

The measurements in the main flue at the entrance to the economizers were carried out by three pyrometers of equal length in such a way that all the pyrometers were placed at equal depths into the setting at a distance of about 400 mm. (15.7 in.) from one another. The thermometers were changed in position several times and the results were always

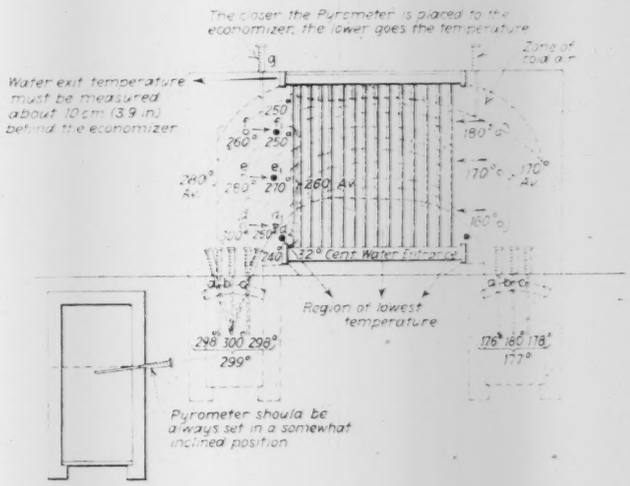


Fig. 3 Temperature Measurements in Evaporation Tests

the same. The two outer thermometers always indicated a little less than the middle one, which leads to the conclusion that both outer thermometers had been somewhat effected by the temperature of the brick work of the side walls. Quite noticeable, however, was the difference in temperature at the three places, *a*, *b*, *c* and *d*, *e*, *f*. The thermometer at *d* indicated always the same temperature, if it was placed low enough. The other two thermometers indicated lower temperatures, so that even in an economizer 3 m. wide one could observe a difference in temperature between instruments placed at *a*, *b*, *c* and those placed at *d*, *e*, *f*—a difference of 30 deg. cent. (54 deg. fahr.) over an average distance of 1½ m. only; the vertical thermometer still less, only about 250 deg. The author noticed, however, that the vertical thermometer at *g* was not placed quite vertically over the three other holes and was inclined somewhat in the direction of the economizer.

Even though this fact appeared sufficient to prove that it is not correct to effect measurements in the front chamber, the author carried out further measurements in the rear chamber of the economizer. Here the difference in temperatures was not as great as it was at the entrance, which ap-

peared to be due to the fact that a very considerable amount of cold air was allowed to enter through numerous leaks and that this materially increased the volume of the gases. Further temperature measurements were then undertaken, the three thermometers being taken out from *d*, *e*, *f* and placed at the same height into the economizer brick setting, where it was found that at the points *d*, *e*, *f* entirely different results were obtained; to wit, 260, 270 and 250 deg. cent., respectively (500, 518 and 482 deg. fahr.). These measurements were effected at a distance of approximately 300 mm. (11.8 in.) from the collector piping, and gave an average figure of 260 deg. cent. Here again 10 deg. have been lost in the distance from the lowest point of measurement of 20 deg. from the entrance to the economizer. Finally, the thermometer was shifted from *d* to *f*, or quite close to the first row of pipes on the lower collector piping, which gave a flue gas temperature of 240 deg. The same operations were carried on with the upper thermometer, but there a difference at most from 5 to 10 deg. could be found.

Further tests were made in the economizer casing at various places, but always along the same vertical line, and it was found that in the lower third part of the economizer the flue gas temperatures were quite low. This difference in measurements is explained by the author on the basis of an assumption that in order to determine the temperature under similar conditions, not only an accurately indicating pyrometer is necessary, but it is also necessary that the measurements should always be effected under practically equal conditions. By this equality of conditions, the author understands that the depth of immersion would be absolutely equal throughout and that the velocity of flow of the flue gases at the spot where the measurements are made would be also equal. He believes that if he were to place three pyrometers in the main flue in such a manner that they would be placed radially and come with their immersion terminals exactly into the middle of the smokestack, there would probably be no difference whatever in their temperature indications. The fact that the difference in temperature between the main flue and the front chamber of the economizer is so great, he believes to be due to the fact that the measurements were not made at the same velocity of flow of flue gases. The author believes, therefore, that all measurements of temperature "at entrance to the economizer" should be made at the spot where the gases pass through the main flue into the economizer casing.

Straight Flow Steam Engine for Rolling Mill Drive, of 700 to 1000 h.p. (*Gleichstrom-Walzenzugmaschine von 700 bis 1000 PS*, E. Zix. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 40, p. 1429, October 3, 1914, 2 pp., 8 figs. *d*). The straight flow steam engine, on account of its simplicity of construction, low steam consumption and, above all, its easy adaptation to fluctuation of load, has found a wide field of application for driving rolling mills where it is displacing the tandem engine more and more. The present article describes an engine delivered to a rolling mill plant some time ago by a German concern. This engine deserves particular attention on account of certain particulars of construction and a special test made on a jet condenser connected with it. It has (Fig. 4 A to C) 750 mm. (29.4 in.) bore and 900 mm. (35.4 in.) stroke. Its speed, which varies from 110 to 140 r.p.m., can be easily adjusted to the requirements of the rolling mill during the operation, by adding supplementary springs to the governor spring. At a steam pressure of 10 atmospheres and 130 r.p.m., the normal output is 700 and the maximum output 1000 indicated h.p.h. At a steam temperature of 300 deg. cent. (572 deg. fahr.) and at least 90 per cent vacuum in the connecting pipe a consumption of 4.5 kg. (9.9 lb.) of steam per indicated h.p. is guaranteed. The cross head (Fig. D and E) is of interest on account of its easy demountability and at the same time fully reliable connection with the piston rod. The Stumpf valve gear which was used on the first engines has been discarded on account of the lack of accessibility of the axle governor and of its limiting the highest cut-off.

At starting, the straight-flow rolling mill engine, to overcome the considerable frictional resistance of the rolls, needs, in the absence of a vacuum, very large cut-offs, at least 50 per cent, and on this account a maximum cut-off of 60 per cent was specified for these engines, which can be obtained by the very simple valve gear shown in Fig. F driven by a lateral shaft. The valves are cast together with their sites and are separated from them only during the machining process. The adjusting gear and spindle of the governor run on ball-bearings. A jet condenser (Fig. G and H) is directly coupled with the steam piston rod and therefore works with very high piston speeds. The lower the condenser pressure, the more favorable are the results on the straight flow steam engine and, therefore, it is desirable to have as high a vacuum as possible, at least 90 per cent. As very favorable experience has been had in this connection, with condensers having no suction flaps, it appeared advisable to use them also in this case notwithstanding the high piston velocities resorted to.

At first many difficulties were encountered, and only after numerous experiments could this design be fully managed. The steam is condensed in a preliminary condenser which, on account of the space requirements, is placed 2100 mm. (say 82 in.) from the center line of the main condenser. The cold water flows into it under a head of 110 in. In order that no water may run over into the steam cylinder in case of a sudden removal of the load from the engine, the piping between the condenser and engine is made 10 meters high (32.8 ft.). At first a vacuum of only 65 to 80 per cent was obtained, the variations in the vacuum being from 10 to 12 per cent. Certain leaks were discovered and eliminated in the piping, without, however, producing any satisfactory results. The preliminary condenser stood about 500 mm. (19 in.) below the main condenser. As the pipe between the two was horizontal, it was thought that the mixture of air and water did not reach the suction chamber of the main condenser in proper time, and this led to locating the preliminary condenser at a higher level so that the mixture should flow into the suction chamber with a head. No material improvement resulted. It appeared therefore that the cause of the trouble lay in the initial process occurring during the flow of the water in the S-shaped pipe and the suction room.

The water level gage was placed at the lower end of the S-pipe and it was found that in that pipe the water column varied quite considerably and irregularly, and further, that sometimes the water entirely filled the admission pipe lying immediately on the condenser. Therefore at certain positions of the water in the S-pipe the admission of air to the suction chamber of the pump was entirely cut off. It ap-

peared that this trouble might be obviated by providing the pipe *R* (Fig. II) with two suction valves so as to handle the air and water separately. Even that did not help entirely, however. The vacuum was made much better and rose up to 90 per cent, but the variations in the vacuum still remained at the undesirably high level of 10 to 20 per cent, and further, from time to time the pump developed a hard irregular pounding which could be softened down only by admitting air on both sides of the pump. With the new arrangement, the great variations of the water level in the S-pipe continued and evidently spread as far as the pump chamber.

As a last resort, it was decided to try the suction of air over the water level. Next, independent air suction cocks were laid at several places from the preliminary condenser to the main condenser and observations were taken to find out which of these cocks should be manipulated to produce a variation in the behavior of the pump. It was found that the nearer one approached the condenser, the better was the action of air and suction. Finally, at the highest point in the suction chamber a pipe, *X*, provided with a cock, was led in and the air suction taken therefrom. This had the desired result. The vacuum immediately improved and is maintained now at from 90 to 95 per cent; the variation in the vacuum comes down to only 1 per cent and the condenser runs quietly, as shown in the original article by indicator diagrams. It is quite likely that by a different arrangement

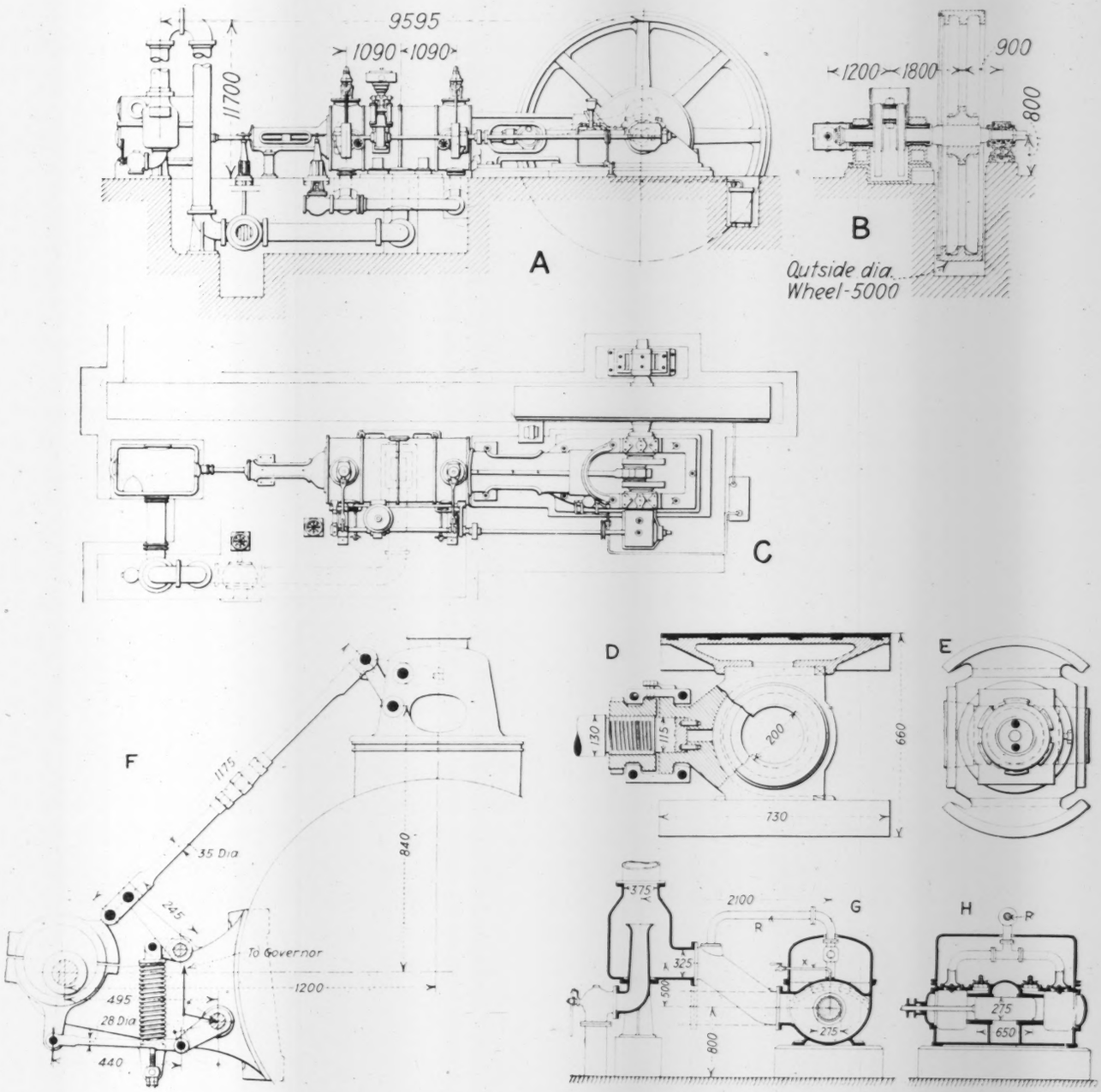


Fig. 4 Straight Flow Steam Engine for Rolling Mill Drive

of the constituent elements and by shifting the preliminary condenser closer to the main condenser, the difficulties described would have been eliminated. In the present case, however, it is interesting to know how an arrangement which apparently could have been expected to spoil the action of the mechanism, actually improved it.

Operating Tests with Indicators and Recording Load Meters (*Betriebsversuche mit Leistungszählern und registrierenden Belastungsanzeigern*, Böttcher, *Dinglers polytechnisches Journal*, vol. 329, no. 40/41, p. 593, October 10, 1914, article not finished, *de*).

The article describes the new type of Böttcher continuous load indicator and a test made with same. (Compare *The Journal*, April 1913, p. 711.) In addition to the indicator

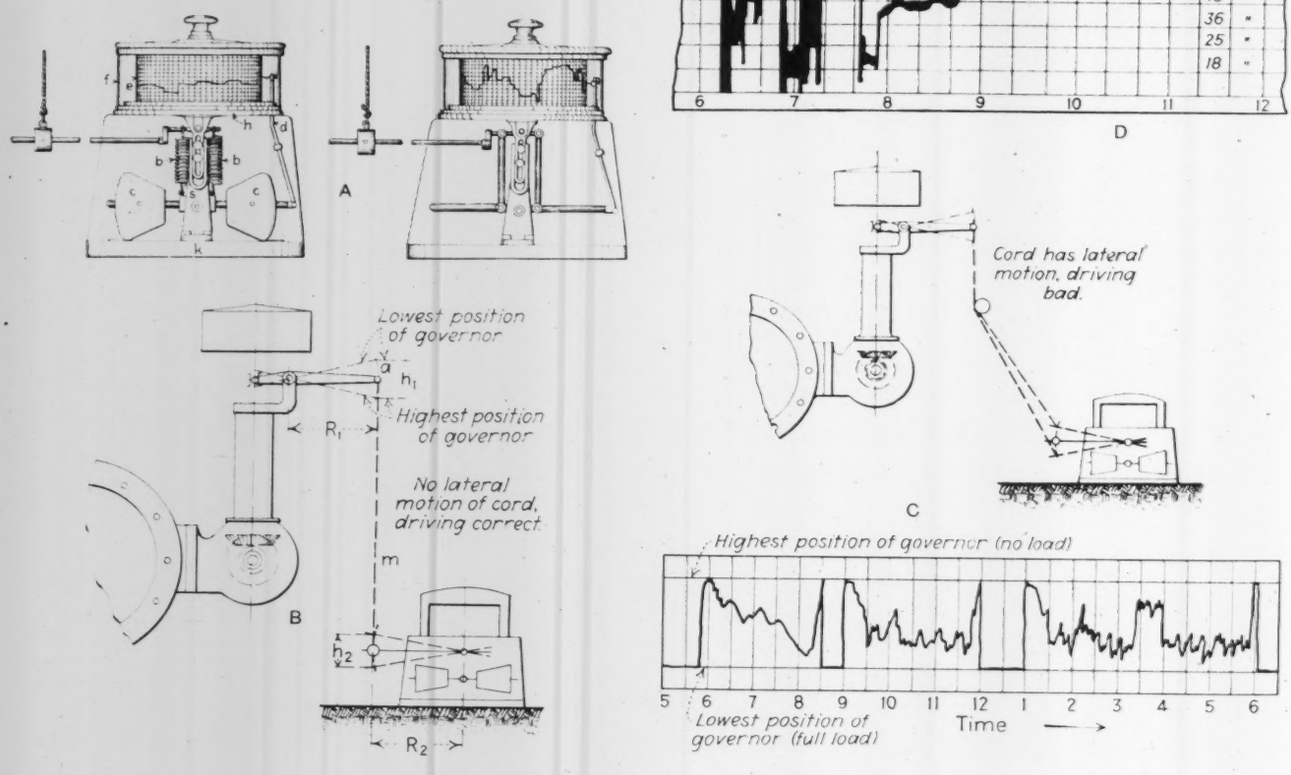


Fig. 5 Böttcher Load Indicator for Continuous Tests

described previously, a new type has lately been developed, the purpose of which is to give practically the same kind of indications as is given by the ordinary registering wattmeter in electric plants. Such an apparatus is shown in Fig. 5 A. The principle made use of in the apparatus is based on the fact that in the centrifugal governor the position of the governor sleeve regulates the operation of the engine, the lowest position giving the maximum admission and the highest position, minimum output or practically no load, each intermediate position corresponding to some output between these two extreme limits, or to a certain pressure of steam admission. The apparatus as shown in Fig. A consists, accordingly, of a balanced mass pendulum, *c*, suspended on two springs, *b*, and rotatable around the point *s*. This pendulum carries at *d* a recording pen, adjustable by means of the lever *a*. If the lever *a* is placed in its highest position, the recording pen is at its lowest point, and vice versa. The recording drum *e* is provided with clockwork and in accordance with the original design makes one revolution in 1, 12 or 24 hours. The mass pendulum begins to operate when the driving lever *a* makes small oscillations about any of its positions. These oscillations are damped out by the mass pendulum in connection with the suspension springs and in this way kept away from the recording pen. Should the engine be free from such oscillations, the mass pendulum with its spring suspension can be replaced by a simple joint parallelogram.

The connection between the governor and the engine is effected in the most simple manner by the arrangement shown in Fig. B. The position of the lever is adjusted for the machine standing still (lowest position) and for the no load run, with the admission valve open as wide as possible (highest position), and then the stroke h_1 is determined for the point of application *a*, selected for driving the apparatus. The weight of the driving lever on which the rolls for the driving cord are fixed is determined in such a manner that the stroke h_2 at its full deflection of the rod *a* be equal to the stroke h_1; the apparatus is then placed close to the engine in such a manner that the connecting cord *m* should have, as far as possible, no lateral motion, while the apparatus passes from its highest to the lowest position. Special arrangements are made only on account of the local condi-

tions, as when the cord has to be placed in an inclined position or with the possibility of lateral motion.

For the estimation of the diagrams obtained with this load indicator, it is essential to bear in mind that while the engine stands still the governor is in its lowest position. During stops, therefore, a line is drawn which coincides with the line of maximum output. Fig. C gives a typical diagram of operation of a steam engine with variable load. While during the period from 8.30 to 9 and from 12 to 1 o'clock the engine did not operate, it ran before 6 o'clock in the morning and also after 6 o'clock in the evening.

The author describes several tests made with this apparatus of which the following are outlined here: During the acceptance trials of a Diesel engine a considerable lack of regularity of operation had been observed. The test of the engines by means of a tachograph proved impossible on account of lack of space. An ordinary speed indicator showed, however, variations in the speed of rotation up to 15 per cent. With the load indicator described in this article, which could be installed without interrupting the operation of the engine, the diagram shown in Fig. D was obtained. The numbers at the bottom of the diagram indicate hours; the plans of the curve show the lowest positions of the governor, either standing still or at maximum output of the engine, while the lowest points of the curve show the engine running at no load. The engine was started at 6.15, ran for a few minutes without load and then on load up to 6.40, during which time the governor, as well as the speed of the engine, showed considerable variation, notwithstanding the constant load. The abnormal variations in the diagram clearly show this lack of regularity. In order to eliminate the fault in the engine, it was stopped for 12 minutes; the result, however, was negative, as can be seen from the diagram. At 7.18 the engine was stopped again and all parts of the governor investigated. It was found that the lever which connected the governor with the crude oil pump jammed in one position. After this fault had been eliminated the engine ran at variable load without further trouble.

The points on the load curve were very interesting where a second Diesel engine was switched in on the same transmission line. As the second engine was set for too small a speed of rotation, the first engine had to drag the second one after it, so that it was carrying an adidtional load to the extent of no-load on the second engine. The necessary adjustment of the second engine was materially facilitated by the indications of the speed indicator. The article is not finished.

New Patents in the Field of Boiler Firing (*Neue Patente auf dem Gebiet der Dampfkesselfeuerung*, Pradel, *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 42, p. 469, October 16, 1914, article not finished, *d*).

The article, which is not yet finished, gives a brief account of new patents granted in Germany for inventions in the field of boiler firing. The grate designed by Pellegrino Fratelli of Turin, Italy, shown in Figs. A, B and C, belongs to the class of grates with bars having longitudinal freedom of motion and automatic advance of fuel. In the neighborhood of the charging hopper in the new grate, instead of former steps, the bars are equipped with parts, such as teeth, notches, etc., on each separate bar, in order to hold the lower layer of coal during firing. In this way the front limit of the firing zone is not allowed to shift too far back. As shown in Figs. 6 A and B, the bars have a freedom of longitudinal motion in either direction in three groups, *a*, *b* and *c*. The bars of these groups are placed alternately side by side, and are located on cross-bars *d*, *e* and *f* of three driving frames, each of the frames being supplemented by a T-bar. In their turn, each of these bars is provided with cams, *k*, *l*, *m*, the purpose of which is to drive the frames and consequently the grate bars in the manner desired, from a driving shaft *n*. The bars in the proximity of the hopper are provided with a number of teeth, so as to maintain a uniform combustion over the entire surface of the grate. While the ordinary traveling grates with overlaid grate bars can move forward and backward, these two motions become impossible in the case of traveling grates with the bars rotatably located at one end and suspended at the other, since during the backward motion of the bars they would take a low position, providing they succeeded in passing under the scraper at *o*.

Thermodynamics

Specific Heat c_p of Air at 60 Deg. Cent. and 1 to 200 Atmospheres Pressure (*Die spezifische Wärme c_p der Luft*

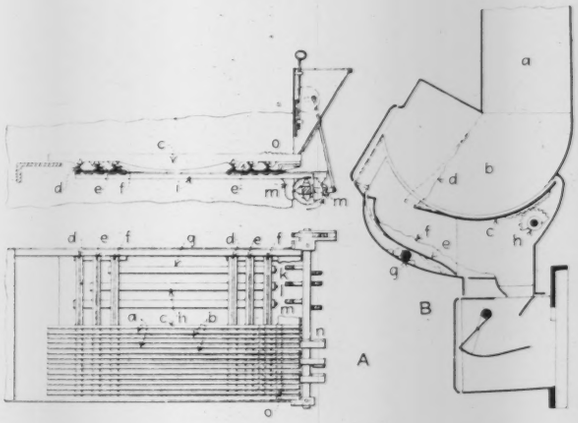


Fig. 6 Pellegrino Grate

bei 60° C und 1 bis 200 at., L. Hornborn and M. Jakob. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 40, p. 1429, October 3, 1914, 8 pp., 16 figs. *eA*). The numerous determinations of the specific heat of air now available apply mainly to atmospheric pressure, while for higher pressures there are only a few. Regnault was the first to determine the relations between specific heat and pressure at average temperatures of from 100 to 60 deg. and pressures between 1 and 13 atmospheres, and he has established that the variation of the specific heat c_p in this region does not exceed the error of observation (1 per cent or more). On the other hand, Lussana has found that when the region of experimentation has extended up to 160 atmospheres, specific heat rises rapidly with the pressure. C. Linde has determined the increase of specific heat with pressure indirectly from the cooling at adiabatic throttling and found it to be much smaller than Lussana. The determination of this specific heat from isothermals at low temperatures made by Witkowski has also given only a slight increase in the values of c_p with the increase of pressure. In view of the fact that the data obtained in the few direct measurements of c_p at high pressures and the indirect determinations of this mag-

nitude are in flat contradiction, the State Institution of Engineering Physics (Germany) has undertaken a new direct determination of c_p at the average temperature of 60 deg. cent. and pressures from 100 to 200 atmospheres. As a method of test, the well known process of continuous flow was selected. The gas to be investigated flows in a uniform current of G kg. per hour, at constant pressure, through a calorimeter and is heated electrically, by supplying it with an amount of heat Q calories per hour, from the temperature of admission t_1 to the temperature of exit t_2. If during this process V cal. per hour are lost, then the specific heat c_p is determined from the equation,

$$c_p = \frac{Q - V}{G(t_2 - t_1)}$$

The loss V depends in this case only upon the distribution of temperature along the surface of the calorimeter. If it is always maintained equal, but at different tests the gas is permitted to flow with different velocities, then the amount G varies and several equations are obtained from which the two unknown quantities c_p and V can be calculated. For the purpose of tests only large air currents can be used, as it is desired that too much influence should not be exerted by the conduction of heat in the pipes which, on account of high pressures used, must be made with fairly thick walls. At maximum the flow of air amounted to nearly 44 kg. (96.8 lb.) per hour. Should it be reduced to one-half or one-quarter of this value, as higher precision of measurement becomes desirable, then the same distribution of temperature along the surfaces of the calorimeter can be maintained only if the pipe through which the flow occurs be surrounded by a liquid which is maintained in constant circular flow and service to equalize the temperature over the entire surface. In the present case, oil was used as such a liquid. The air entered with the temperature t_1 of about 20 deg. cent. the calorimeter and, through heat Q supplied by two electric heating bodies, was heated up to a temperature t_2 = 100 deg. cent. The oil was also maintained at this temperature. In order to make the loss V small, the entire calorimeter was surrounded by a jacket through which steam was flowing. The air G, which was allowed to expand to atmospheric pressure after the exit from the calorimeter, was measured by means of a gasometer.

New Experiments on the "Undercooling" of Saturated Steam Flowing Out of Nozzles (*Neue Versuche über die Unterkühlung beim Ausfluss gesättigtem Dampfes*, Prof. A. Stodola. *Schweizerische Bauzeitung*, vol. 64, no. 15, p 168, October 10, 1914, 3 pp. *eA*). In a previous investigation the author found that when initially saturated steam flows out of a nozzle or similarly acting appliance it remains almost perfectly undercooled during the expansion up to the smallest section of the device through which the exit of the steam is effected. In the case of a nozzle at certain limits of saturation there occurs, immediately behind the smallest cross-section, a sudden increase of condensation which produces a rapid fall of undercooling.

Since then two more tests have been conducted for the purpose of elucidating this particular phenomenon. As has been explained before, for the determination of the state of end cooling in any cross-section it is necessary to know the weight of steam flowing per second G, absolute pressure p, cross-section f, and velocity of flow w. If we limit our investigation to the state in the *end* cross-section of a nozzle, the velocity of steam can be determined in the best way by measuring the jet reaction. For this purpose the author used the device suggested by Frederick and Kembel or that of Christlein, by means of which the reaction with the total capacity of about 10 kg. could be determined with an exactness of 5 gr. At the end of the nozzle, however, there may be a pressure above atmospheric about which no information is given by the reaction measurement, and the problem is raised of devising methods for the special measurement of reaction at such a relation of pressures where the steam in the end cross-section expands exactly to the back pressure of the surrounding medium. For this purpose there was placed within 3 mm. from the end of the nozzle a brass tube with well rounded inward edges 1 mm. in diameter, and the pressure in it observed through a properly placed branch tube. The pressure at the end of the nozzle could then be calculated analytically with sufficient precision. If during the test this pressure be considered as back pressure, then the measurement of reaction would indicate the desired end velocity. The nozzles investigated were of conical shape, and had at the inlet a curve of a radius equal to the diameter of the smallest cross-section.

The author has previously shown that the equation of continuity makes it necessary that the area of the end section be inversely proportional to the amount of undercooling. The data of the tests are given in Table I. The figures of Table A raise a question how it may happen that even with perfect condensation the actually available end section does not appear to be filled up. It is true that the amount lacking appears to be very small (1.8 to 2.3 per cent), but, considering the care taken in the measurements, it cannot be due to errors of observation. One might suppose that, while the steam is saturated, *the particles of water are superheated*, and that there is therefore no uniform temperature level throughout the end cross-section; but, in order that a continuous state be maintained the temperature of the water drops, would have to be negative, or the end section would not be filled up. There must be some other explanation of this phenomenon, therefore, and the author attempts to give it in the following lines.

He starts with the investigation of what he calls the *real equation of continuity*. As a rule in engineering work, a uniform average state in a cross-section and an average velocity are presumed to exist. Actually, however, even in straight line flow only the pressure can be considered as being sufficiently uniform; the velocity decreases from the center to the walls, while the specific volume increases in the same direction due to the greater heat of friction developed in the neighborhood of the walls. Although, according to Prandtl, the main work of friction is developed within a thin layer close to the wall, while for the rest of the section a nearly adiabatic flow may be assumed, even the smallest lack of uniformity affects the equation of continuity in a very noticeable manner, and thereby the state of the steam. The author proceeds to show this. To do it, he derives a series of equations which show that, in the case of a "two-dimensional" flow the linear average value of the average velocity of flow does not agree with the square of the average value. Further, it is not correct to add the losses of flow to the average velocity of flow, but fortunately the error due to this fact does not exceed 1 per cent. The experimental work done appears to permit one to answer with a considerable degree of reliability the question as to the state of steam at the end

of the nozzle. It appears that the condensation at the end of the nozzle does not reach its theoretical value, but the undercooling is small, and inversely proportional to the amount of expansion. Further measurements could have permitted a precise formulation of the law, in accordance with which occurs the decrease along the axis of the nozzle of the almost perfect undercooling of the smallest section, but the outbreak of the European war forced the author to give this up for the time being.

TABLE 1 TESTS ON UNDERCOOLING OF STEAM. DATA CONCERNING THE TEST INSTALLATION

	Nozzle 1	Nozzle 2
Smallest diameter, mm in.	12.06/.474	12.07/.475
End diameter, mm in.	18/.708	25.12/.988
Distance between the smallest and the end section, mm in.	150/5.90	150/5.90
Absolute initial pressure, p_1 kg/qcm, lb. per sq. in.	8.15/126	11.15/158.5
Initial temperature, deg. cent. fahr.	174/345.2	197.5/387.5
Absolute initial temperature, deg. cent.	447	470.5
Absolute end pressure of expansion, p_2 kg/qcm, lb. per sq. in.	1.082/15.32	0.571/8.11
Ratio of pressures, p_1/p_2	7.53	19.52
Specific initial volume, m_1 kg. cu. ft. per lb. v_1	0.2440/3.29	0.1872/2.9
Weight of steam per second, G, kg/lb.	0.1351/0.2972	0.1809/0.3979
Coefficient of outflow x in the formula G.	2.044	2.046
Jet reaction P, kg	10.85	17.60
Average steam velocity at nozzle end, m/sec, ft. per sec.	787.7/2582	954.5/3131
Initial heat content, WE B.t.u. per lb.	665.9/1198	675.5/1215
Initial entropy	1.6046	1.5929

A. Final state at normal expansion and theoretical condensation

Absolute pressure, kg/qcm, lb. per sq. in.	1.082/15.32	0.571/8.11
Adiabatic heat content, WE B.t.u. per lb.	582.6/1048	550.72/994
Adiabatic specific amount of steam	0.8930	0.8615
Adiabatic heat fall, WE B.t.u. per lb.	83.28/150	118.3/213
Loss in per cent of adiabatic fall, per cent	11.05	8.00
Heat content of effective final state at theoretical condensation, WE B.t.u. per lb	591.8/1065	566.5/1019
Corresponding specific amount of steam	0.9101	0.8782
End cross-section as per equation of continuity, qcm sq. in. f	2.498/0.385	4.842/0.740
Actual end cross-section (cold) f qcm sq. in.	2.545/0.3937	4.955/0.767
Difference in per cent, $f-f$	1.84	2.28

ENGINEERING SOCIETIES

AMERICAN IRON AND STEEL INSTITUTE

Birmingham Meeting (reported from Steel and Iron, vol. 48, no. 41).

Use of Turbines for Various Purposes, F. G. Cutler (abstracted)
The Repair Department of the Modern Steel Plant, John Hulst

Use of Turbines for Various Purposes, F. G. Cutler (3 pp., 6 figs., *de.*). The paper describes the application of turbo-driven equipment, at the Ensley Plant, of the Tennessee Coal, Iron and Railroad Company. The author calls attention to the great reduction of power costs and savings effected by improvements in machinery, such as the installation of condensers on non-condensing units and improvements in economy by the installation of apparatus of higher efficiency, such as low or mixed pressure turbines. At the Ensley Plant, 7 years ago, there were seven boiler houses and two electric power stations of a total rated capacity of 1800 kw. and a third power station of 1800 kw. which had just been completed. All of the engines operated were non-condensing and no power was supplied to outside plants. Later, as a result of the installation of low pressure turbo-generators with condensers and cooling towers, and the installation of low pressure turbo-blowers with condensers and cooling towers at the blast-furnace blowing engine house, two boiler plants could have been dismantled entirely, one is operated only occasionally and two more at the steel plant are operated only during the time that the mills are running. At the same time, electric power is supplied to several plants in the neighborhood and to a street railway line, the result of which is the shutting down of several boiler plants and the reduction in load of others. The saving in coal with the present equipment and methods of operating over the former practice is estimated to be at the rate of 200,000 tons per annum. In one of the power houses, three 3000 kw. generators are driven by mixed pressure turbines supplied with exhaust steam through five regenerators, each 8 ft. in diameter by 51 ft. in length, from two 55 in. by 66 in. twin reversing engines. The capacity of these regenerators is sufficient to absorb the extreme fluctuations in the steam delivery without raising the back pressure on the engines over approximately 4 lb. At another power-house, three Corliss engines drive 600 kw. generators and one Corliss engine drives a 2000 kw. generator, the exhaust of these reciprocating engines being connected with a 3000 k.w. mixed pressure turbine without the regenerator, which is here eliminated on account of the relatively steady load. The turbo-blower equipment is operated by two mixed pressure turbo-blowers, each of 55,000 cu. ft. per minute capacity. One of these turbo-blowers was originally a high pressure turbine driven machine. Fairly complete steam consumption tests have been made, the principle data of which are given below. In these tests, the actual blast delivery was taken at 307.5 cu. ft. per revolution, the intermediate h.p. being based on indicator card results. The steam consumption of 2.09 lb. from 100 cu. ft. of actual blast corresponds to 18.5 lb. per indicated h.p.h. When operating non-condensing against a 2 lb. back pressure, the steam consumption per 100 cu. ft. of blast at 15 lb. is about 3 lb., corresponding to a gross saving of 30 per cent by condensing these blower engines.

The Tennessee Company was the first in this country to install turbo-blowers and exhausters in by-product work and probably the first anywhere to use them exclusively. There is a peculiar advantage in the use of turbo exhausters in the by-product service in that the centrifugal action of the blower throws out the small particles of tar fog carried with the gas, which almost eliminates the work required of the tar extractors located between the exhausters and the saturators. Of the total tar production of the plant, three per cent is recovered from the operation of the turbo exhausters. The speed and delivery of both exhausters and boosters is controlled by a float attached to the governor, the position of this float being determined by the suction pressure.

AMERICAN SOCIETY OF CIVIL ENGINEERS

Vol. 40, no. 8, October 1914.

Fundamental Principles of Public Utility Valuation, John W. Alvord
The Valuation of Public Utility Property, J. H. Gandolfo
Investigation of the Performance of a Reaction Turbine, R. L. Daugherty (abstracted)
The Differential Surge Tank, Raymond D. Johnson
Penstock and Surge-Tank Problems, Minton M. Warren

Investigation of the Performance of a Reaction Turbine, R. L. Daugherty (18 pp., 12 figs. *e.t*). This article

describes a careful and accurate test of a 550 h.p. reaction turbine recently installed at Cornell University, in which, in addition to the regular load test at constant speed, the torque, head and discharge were measured at zero speed and readings were also taken of speed, head and discharge under no load so as to obtain, approximately, a complete characteristic curve for the turbine. The turbine selected was rated at 550 h.p., at 600 r.p.m. under a head of 142 ft., had a runner 27 in. in diameter and was directly connected with a 450 kva., 2300 v., 3-phase 60-cycle alternator. The article describes in detail the method of estimating the head in a turbine test, which is a matter of agreement in any case. The rate of discharge was measured with a suppressed weir in the tail race and was computed by the modified Francis formula:

$$q = 3.33\ L\left(H + \frac{v^2}{2g}\right)^{\frac{3}{2}}$$

Where q = cu. ft. per second; L the length of crest, in ft.; H the head on weir, in ft., and v, the velocity of approach in ft. per second. If the velocity of approach is uniform over the entire cross-section of the channel, this formula is reasonably correct. In other cases, the actual velocity near the surface is much greater than the mean velocity, and then the effective velocity head is greater than that determined from the mean velocity. In the test, runs were made under various loads at the constant speed of 600 r.p.m. The turbine was also held from rotating and the torque at various gate openings was measured by a system of levers and standard weights. In addition, the turbine was permitted to turn at runaway speed, the only load on it being the friction and windage of the generator. In order to determine fully the characteristics of a turbine, however, it is necessary to test it a little above or below normal speed at various gate openings under several relations of speed to head. In the test under discussion, the head was throttled down by the gate valve to about two-thirds of its normal value and the load run was made under the regular speed of 600 r.p.m. Values of the ratio of speed to head were obtained higher than normal.

The relations between torque and speed or discharge and speed as shown by the curves in the article, are not a straight run but on a suitable scale may be represented as a fairly flat curve. From the curves showing the relation between the torque and speed or discharge and speed, the efficiency may be computed at any intermediate point and if these are the characteristics, curves may be constructed covering every possible condition under which the turbine may operate. The results are given in the form of tables and curves.

AMERICAN SOCIETY OF MARINE DRAFTSMEN

Journal, vol. 1, nos. 1 and 3, April and October 1914, Washington, D. C.

April, 1914, No. 1

U. S. Submarine Tender "Fulton," D. R. Battles

Relation of Length and Displacement to Indicated Horse Power, F. P. Knowles

Determination of the Sag of a Suspended Wire, L. H. Kenney (abstracted)

October 1914, No. 3

Designing Modern Marine Machinery, Luther D. Lovekin

The Industrial Organization of Our Navy Yards, Elliott Snow

Steam Pipe Velocities for Turbines, W. B. Robins (abstracted)

Experiments to Determine the Sag of a Suspended Wire, L. H. Kenney (3 pp., 1 fig., i chart, *cp*). The article describes experiments made at the Philadelphia Navy Yard to determine the sag of a suspended wire. Their purpose was to determine the amount of correction necessary in the formula for the sag of the wire and they describe in detail the apparatus used. The main element was a narrow tank about 170 ft. long, constructed for this purpose. The tensile strength of the wire was first determined and the wire was stressed during the experiment slightly below the elastic limit, so that it would not be stretched and so that no errors would be introduced in this way. The standard level for the test was gaged from the water level in the tank and as there was an evaporation loss which appreciably lowered the water level, provision for replenishing the water was made by placing three reservoirs along the sides of the tank. The data obtained from the experiment were plotted and the formula of the catenary was first applied to the result, but it was found that the curves did not conform to the formula. Then the formula of the parabola $Y^2 = 2px$ was applied and the curves were found to correspond to it, which was very fortunate since it was a comparatively simple matter to compute the sag for any desired distance from either end of support. The article gives a graphic method for obtaining all deflections from one curve, as well as the curve of deflection of wire for alignment of shafting.

Steam Pipe Velocities for Turbines, W. B. Robins (2 pp., *dp*). The article gives data on steam pipe velocities for turbines with data of steam velocities in feet per minute on United States destroyers and battle ships:

Type of Vessel	Per cent of full power	Steam per S. H. P. per hour	Steam Velocity in Feet per Minute	
			In branch from each boiler in use	In steam pipe to first turbine of series in use
T. B. Destroyer	100	14.7	5200	6090
	54	13.3	2560	6825
	11	26.6	2330	7910
T. B. Destroyer	100	12.5	7040	8245
	41	14.7	4490	11650
	8	21.5	4380	7375
T. B. Destroyer	100	14.2	6025	6300
	54	14.7	4390	9925
	11	23.3	4365	7420
T. B. Destroyer	100	14.2	5900	6165
	56	14.7	3390	10210
	11	23.0	4315	7330
T. B. Destroyer	100	14.0	6215	6500
	53	13.8	4290	9690
	10	22.5	4310	7320
T. B. Destroyer	100	14.1	5810	6075
	55	15.0	3320	8830
	12	22.5	2215	7550
T. B. Destroyer	100	15.7	5740	6010
	53	16.7	3225	8575
	11	25.6	2110	7170
Average at full power		14.2	5990	6484
Battleship	100	13.2	5740	6680
	52	14.2	3230	3760
	12	20.4	3890	1294
Battleship	100	15.0	7200	5915
	63	15.3	4610	7570
	15	25.2	3605	5925
Battleship	100	14.4	8350	6870
	66	15.1	5660	9300
	17	23.6	3370	7380
Average at full power		14.2	7097	6488

BRITISH ASSOCIATION

TEMPERATURE CYCLES IN HEAT ENGINES, Professor F. G. Coker and W. A. Scoble. The following abstract of the paper in Section G of the British Association in Australia has been taken from Gas and Oil Power, September 3, 1914, page 272, as copies of the original paper are not yet available.

Experimental investigations of the cyclical variations of heat-engines and heat-pumps have received much attention, and numerous methods and instruments have been devised to give records of their cyclical changes, such as those of pressure and volume of the working fluid, changes of angular velocity of the crankshaft, and the like. Temperature changes in the working fluid may usually be inferred very accurately from the pressures recorded on an indicator diagram, since there is usually a definite relation between pressure and temperature of a vapor as, for example, in heat-engines using steam direct from a boiler without the intervention of a superheater. In other heat-engines, such as those using superheated fluids, and also those of the internal-combustion type, the temperature is more difficult to determine, and it becomes important to measure it directly. Platinum resistance thermometers and thermo-electric couples have been frequently employed for measuring cyclical changes of temperature in heat-engines, and a complete record from point to point of a cycle may be obtained if the engine is working with absolute uniformity. As it is usually impossible to prevent some amount of variation in the working of the engine while the measurements are in progress, the resulting curve is a composite one, since each measurement corresponds to a different temperature.

The possibility of obtaining an instantaneous automatic record with an Einthoven type of galvanometer, was considered in our early experiments on the cyclical variations of temperature of the working fluid of a gas-engine, and in the walls of the cylinder, but the difficulties then appeared to be so great that a potentiometer balance method was used instead. Recently, by the kindness of the Cambridge Scientific Instrument Company, we have been able to make experiments with their latest form of short-period Einthoven galvanometer, and this has enabled us to obtain instantaneous records of the temperature-cycles of the working fluid of steam and gas-engines, and also the variations of temperature in the walls. Some of these photographic records are shown, and their detailed characteristics are considered in the paper. They confirm the general accuracy of our former measurements on cyclical variations of temperature in a gas-engine cylinder, and also show some new features due to variations from stroke to stroke caused by misfires and the like.

SEVENTH REPORT OF THE GASEOUS EXPLOSIONS COMMITTEE. The Seventh Gaseous Explosions Report presented by the Gaseous Explosion Committee of the British Association at its recent meeting in Australia is reported here from the *Gas and Oil Power* of September 3, 1913, page 274, as the official text of the report is not yet available. One of the problems requiring solution was the direct measurement of temperature of the working agent in the cylinder while the engine was running under ordinary working conditions. The difficulty of making these measurements arises from the fact that during the explosion of the charge in the engine cylinder, the temperature is sometimes higher than that of the melting point of the platinum coupling, which can be put in the cylinder to make the measurement. Professors Callendar and Dalby have devised a method shown in the article which enables direct observation of the suction temperature to be made if the engine is working not only under normal conditions, but under special conditions. During the work, the richest possible mixture is used and the temperature reached at its closure is considerably higher than that occurring in practice. The main elements of this apparatus are a platinum thermometer exposed in the cylinder and connected with a Wheatstone bridge, and a galvanometer on which the indications are received; the circuit is made by a contact maker on the crank shaft, when the crank passes through an assigned crank angle, and broken by the contact maker, when the crank passes through the second assigned crank angle, a little greater than the first, so that the thermometric measuring device is in operation during 5 deg., 10 deg. and 15 deg., as the case may be. In this way, the time between the making and breaking may be adjusted with accuracy. The temperature is measured therefore during a particular crank angle determined by the setting of the contact maker.

In this manner the mean temperature over the small crank angle can be measured at any point in the cycle, except only during the period of explosion when the thermometer is withdrawn from the cylinder. It is, however, generally desirable to measure the temperature at the point on the cycle where the rate of change of temperature is at a minimum. This point occurs just after the closing of the suction valve. The great advantage of making the measurement at this point is that the thermometer is exposed to the incoming charge during the whole of the suction stroke, and therefore the thermometer valve tends to assume the temperature of the charge. Consequently, the temperature which the small wire is set to measure does not differ greatly from the temperature of the metal in which it is mounted, which tends to minimize the errors of measurement. Elsewhere, the rate of change of temperature is greater and the error of measurement likely to be greater, owing to the lag of the thermometer. While, for example, on the expansion stroke, the temperature may vary as much as 150 deg. during the movement of the piston through one-tenth of the stroke, just after the closing of the suction valve the variation of the temperature during a similar part of the stroke is only about 20 deg.

From the temperature at one point in the cycle, that at any other point may be calculated by using the charge itself as the thermometric agent for which it is only necessary to take an indicator diagram at the time of measuring the temperature. To make this method give good results, however, it is necessary to have accurate indicator diagrams from which to measure the pressure and volume, and this leads to the development of an optical indicator.

The second method of measuring the temperature of the charge in the cylinder is by means of a couple and has been developed by Professor Coker and Mr. Scoble at the Technical College in Finsbury. It was found that alloys of platinum, rhodium and iridium were able to withstand the temperature of explosion near the walls of the cylinder for some hours and often days. Any thermo-couples, 0.0005 to 0.0008 in. thick, would do, provided the engine was not overloaded. The actual temperature measurement is then made by observing the change in the electro-motive force

produced in this couple by a change in temperature. The report describes a bridge which permits measuring with great accuracy the small changes in the electro-motive force produced by a couple of this kind.

Measurements of suction temperature were made at the City and Guilds Engineering College on a Crossley gas engine with the cylinder 7 in. in diameter, 14 in. stroke and with the compression ratio of 4.8, the object of the experiment being to show how the suction temperature varies with the speed, the jacket temperature and the mixture. The report also contains a discussion of the first law of thermodynamics and the quantity necessary to apply, to determine the heat lost and gained by the working charge during the change of state. The aim of the Committee was to ascertain the true value of the specific heat at constant volume, Kv, or in other words, to ascertain the relation between the integral energy of the gas and minimum temperature. A relation was obtained expressing the characteristic equation for gases independently of the specific heat of the gases concerned. It applies to all positions of the set point in the PV diagram, providing the two following conditions are satisfied: viz., that there is no change in the density of the gases such as may be produced by some change in its chemical constitution, and further that the weight of the working agent during the change of state is constant. Providing, therefore, that these conditions are not violated during the change of state, it is possible by means of the temperature corresponding to at least one position of the set point in the diagram, and the characteristic equation for gases, to calculate the temperature corresponding to any other position of the set point in the diagram.

CENTRAL RAILWAY CLUB

Proceedings, vol. 22, no. 4, September 1914, New York City.

Locomotive Arch Brick, George Wagstaff (24 pp., 6 figs. *dp.*). The article is devoted to the discussion of the locomotive arch brick. It takes up the whole subject from the clays used in the manufacture of the brick up to the formation of the arch brick, its moulding, drying and baking.

It is estimated that there are at the present time in the United States and Canada, about 30,000 engines equipped with fire brick arches, the majority having tube supported arches; between 7,000 and 8,000 are stud supported arches; about 3,000 oil burners and a small number have the Gaines combustion chamber. The latter apparently has quite a promising future.

The author discusses several questions often raised by locomotive engineers, such as the responsibility of the arches for the cinder banking on them; the space necessary between arch and flue sheet; the influence of arches on the leaks and ground bolts and the question of arch tubes. In the discussion which follows, the question of cinder banking, especially as affected by the design of the front end of the arch, has received a good deal of attention and data of tests of engines equipped with brick arches and those not so equipped, have been presented.

FRANKLIN INSTITUTE

Journal, vol. 178, no. 5, November 1914, Philadelphia, Pa.

Internal Stresses in Heat-Treated Axles, H. V. Wille (abstracted)

Progress in Industrial Fellowships, Raymond F. Bacon

Internal Stresses in Heat-Treated Axles, H. V. Wille (28 pp., 12 pp., *ct*). The article describes a series of experiments conducted upon two 10 in. driving axles about 6 ft. long, for the purpose of determining the internal stresses in forgings after heat treatment. The axles were hollow bored with a 3 in. hole and were heated to 1500 deg. fahr., quenched in oil and then immediately removed to an annealing furnace and annealed at 1200 deg. The object of the tests was to determine the magnitude of stresses in the axles due to heat treatment. The axles were made of open hearth 0.50 per cent carbon steel with 0.037 phosphorus and 0.038 sulphur; elastic limit 54,000 lb. and tensile strength 88,500 lb. They were made from blooms of the same size and given the same reduction and number of heats in forging. Both were treated to the same temperature for quenching and drawing back and were held in the furnace the same length of time for these operations. Both were quenched in the same oil tank, the difference in treatment being the method of quenching, as one axle was lowered horizontally and the other vertically into the oil. Each axle was cut in half at the works of the manufacturer after heat treatment, one half being made into tensile test specimens and the other half reserved for these experiments. Strains were obtained by carefully measuring the specimens before and after their removal from the axles. The stresses were calculated from the measured strains. Two methods, (*a*) and (*b*), were used to obtain the strains.

Method (*a*), which was used at the Watertown arsenal some years ago by the U. S. A. Ordnance Department for the determination of strains in gun forging, is as follows: concentric rings were removed from the forgings and their diameters and thicknesses measured at several points *before* and *after* removal. From the diameters and thicknesses of the attached rings the mean diameter could be found and similarly after removal from the axle their mean diameter is again found and from the difference between these results, assuming that the rings remained circular, the strains and stresses were calculated. Generally, the mean diameters of the rings were found to be larger after removal than before, but in a number of cases this was not true, indicating that the ring did not remain circular but assumed some shape which it was not possible to follow from the measurements of diameters.

Method (*b*): A measurement of changes in length of specimens was made by means of a comparator, the measurement being done in this case by measuring the small changes in length by means of a microscope and the "standard of comparison." The measurement of a straight specimen under this method is as follows: specimens were laid out on a smoothly finished surface, and marks by means of a very fine scriber were made along the ends of a hardened steel scale of a definite length. Then a standard of comparison, slightly shorter than the steel scale and made of the same material as the specimen to be measured and shaped, was placed between the marks on the specimen. A microscope with Filar micrometer attachment was focused on the end of the specimen and the distance between each end of the standard of comparison and the marks on the test piece was measured before the specimen was cut off. In addition to the marks, perpendicularly to the axis of the specimen, a line was drawn parallel to the axis, there being also longitudinal marks on the ends of the standard of comparison which, in measuring, were placed on the longitudinal line of the specimen in order to have it always in the same position with

respect to the axis of the specimen to be measured. The length measurement was repeated after the specimen was removed. The length of the standard of comparison must of course be the same in each measurement and for this reason the standard should be made of the same material as the bar to be measured in order to avoid complications due to differences in temperature. The stresses in specimens are never distributed entirely symmetrically in the test specimens and this may cause the specimen to bend, in which case the measurement at the removal of the piece would not be entirely accurate unless means were taken to keep the specimen straight. In the present experiment, however, bending was noticed only in the longitudinal pieces cut from the inside of each axle where the results have been corrected for this condition.

The author describes in detail the process of the removal of specimens; the calibration of the Filar micrometer, and the calculation of strains. The results are given in the form of tables and curves. The average of the strains calculated show that in the case of rings, stresses produced by horizontal immersion are invariably higher than those produced by vertical immersion, the difference being approximately 10 to 15 per cent. In the case of stresses in longitudinal specimens, the stresses produced in the axles by horizontal immersion are considerably greater than those produced in vertical immersion for compression, but very much less in tension. Further, with the vertically quenched axle, the stresses are maximum near the outside surface and near the surface of the center hole, and minimum half way between these two points, while with the horizontal quenched axle, the stresses do not tend to rise to so high a maximum near the center hole. In regard to the internal stresses released in radial specimens, the plot shows that one side of the section of the axle immersed in quenching horizontally is in tension and the balance in compression whereas the stresses in the axle immersed vertically are compressive throughout the entire section.

In general, the author found that the method (*a*) does not furnish the desired results as only relative values of the mean stresses in concentric rings can be obtained and the difference in stresses in the various parts of the rings are not shown. The stress on different points of concentric rings is generally considerable and the influence of quenching in the vertically quenched axle is much greater than in the horizontally quenched axle. Heat treatment apparently has a much greater effect upon the vertically quenched than upon the horizontally quenched axle, the stresses being greater and apparently somewhat more evenly distributed in the former than in the latter. It is very possible and probable that the stresses are distributed more or less unsymmetrically throughout the length of the axle with respect to a plane perpendicular to the axis in the vertically quenched axle and with respect to the axis itself in the case of the horizontally quenched axle. In order to investigate this, it would be necessary to take specimens from both ends and the middle of the axle.

INSTITUTION OF MECHANICAL ENGINEERS

Journal, No. 2, October 1914, London.

The Discharge of Steam Through Nozzles, Dr. W. E. Fisher (abstracted)

The Theory of the Flow of Gases Through Nozzles, J. G. Stewart (will be abstracted in a future issue)

Advance Paper E (read on October 16, 1914)

Report of the Refrigeration Research Committee (abstracted)

THE DISCHARGE OF STEAM THROUGH NOZZLES, Dr. William E. Fisher (19 pp., 11 figs. *text*). The present article is the second part of the paper on the discharge of steam through nozzles. It describes experiments which had for their object the measurement of the actual discharge from nozzles when the supply pressure was kept constant and the back pressure varied. Slightly superheated steam was employed, very nearly constant in temperature. The article describes the arrangement of apparatus. The nozzles at the smallest section had the diameter of $\frac{1}{4}$ in. The results are given in the form of curves showing the discharges measured, and tables giving the figures for the discharges and also for the temperature of the steam supplied. The discharge became less when hotter steam was used. With divergent nozzles (Fig. 7 "*a*") the discharge remained practically at its maximum value until the back pressure was increased to about 0.8 of the supply pressure, or 172 lb. per sq. in. absolute. When the supply pressure was 110 lb. per sq. in., the back

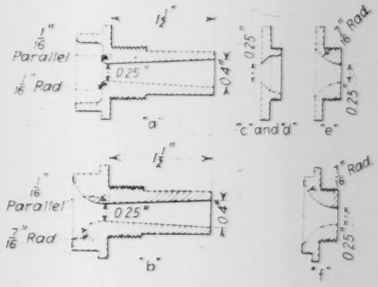


FIG. 7 STEAM NOZZLES

pressure was raised to 0.9 of the supply pressure before the discharge fell away to any considerable extent. Similar results were obtained with nozzle "*b*" having a 1 in 10 taper outlet and abrupt inlet. The vertical discharge as calculated from the tables of Marks and Davis was 425 lb. per hour, and this was almost exactly the measured value obtained when using the nozzle "*a*." The coefficient of discharge was therefore unity. With sharp edged orifices "*c*" and "*d*" the curves are somewhat irregular.

In tests with nozzle "*d*," which had no wire edge, the discharge, as is usual with sharp edged orifices, varied continuously with the back pressure, but there is a point at which the rate of variation of the discharge changes suddenly. It seems fair to assume that this value of the back pressure is the critical or throat pressure, since there is no chance of the overexpansion and recompression which takes place in nozzles. In nozzles without diverging parts ("*e*" and "*f*") the discharge was constant for low back pressure and began to fall away gradually at a certain point, but without discontinuity. With nozzle "*e*" (without parallel part) the first lowering of the discharge took place at a pressure of about 83 lb. per sq. in., or 0.48 of the supply pressure. With nozzle "*f*," the short parallel portion caused the point of change to rise to 100 lb. per sq. in., or 0.58 of the supply pressure. It appears that even in this short length, steam recompression takes place.

The above experiments indicate that the critical pressure is in all cases lower than the theoretical value which can be

caused by a steepening of the expansion line (on the pressure-volume diagram pressure) previous to the throat. The discharge coefficient has in no case been found to be greater than unity, and even these discharges are surprisingly high for the small size nozzles with consequent importance of skin friction and also the possibility of the stream having a true throat area smaller than the least section of the nozzle. Steepening of the expansion line corresponds to heat losses in the entry to the nozzle, but the observed fall in the critical point can hardly be accounted for by heat conducted away by the nozzle, and if the lowering of the critical pressure below the theoretical value be explained by an increase in the expansion index, it is the opinion of the author that some other physical cause for the disappearance of heat must be looked for.

Report of the Refrigeration Research Committee (46 pp., 16 figs, 3 sheets of charts. *gA*). The Committee considered first what standard, if any, could be used for the practical rating of refrigerating machines. As a means of expressing the amount of refrigerating effect of which the machine is capable, under specified conditions such as occur in ordinary practice, two points are involved, viz., first, the unit in which refrigeration is to be measured and stated, and the temperatures between which a machine should, for the purpose of rating, be assumed to act; and second, the question as to what theoretical cycle of action should be adopted as a standard for comparison with the actual performance of a refrigerating machine, working under any conditions, as a means of judging how nearly the real action approaches the ideal. The following recommendations have been made:

The standard for practical rating must be based on the amount of heat extracted per unit of time and the temperatures between which the machine works as a heat pump, viz., the temperature of the source from which the heat is taken and the temperature at which the heat is discharged. It was recommended, *first*, that the refrigeration produced by a refrigerating machine be expressed in calories per second, which unit is equivalent to 342,860 B.t.u. per day of 24 hours; *second*, that refrigeration may be stated for particular or for standard conditions; *third*, that the standard conditions be defined as follows: the temperature limits to be steady; the temperature of the cooling water to range from 15 deg. cent. (59 deg. fahr.) at inlet to 20 deg. cent. (68 deg. fahr.) at outlet, and the temperature of the brine range from 0 deg. cent. (32 deg. fahr.) to —5 deg. cent. (23 deg. fahr); *fourth*, that the refrigeration produced under standard conditions be called the rated capacity of the machine. In cases of cooling by direct expansion without the use of brine, the same method of rating will apply except that the conditions have to be modified by specifying for the lower limit of temperature that of the working substance itself; *fifth*, in the rating of the direct expansion refrigerating machine, the temperature of the vapor in the evaporator be taken at —10 deg. cent. and the conditions in regard to the cooling water be the same as those laid down for the machines using brine. The temperature of —10 deg. cent. as a lower limit for the working substance harmonizes with the conditions which have been laid down for machines using brine and is also in accordance with the standard of temperatures adopted by the French Association on Refrigeration.

In regard to the theoretical cycle of compression, main attention is paid to the internal action of the working substance and the temperatures to be considered are not those external to the machine but those of the substance itself at various stages of the cycle. The theoretical performance in a vapor compression machine using any assigned working substance assumes that adiabatic compression takes place between the constant pressure limits of suction and discharge. These two pressures have to be known and also the temperature to which the working fluid may be cooled before passing the expansion valve. With these data, there will, for any working substance, be some particular degree of dryness, giving the maximum coefficient of performances in the ideal cycle. When the degree of dryness at the beginning of compression is determined, the temperature of superheating reached at the end of compression follows. The essential data, therefore, for determining the ideal cycle are the suction and discharge pressures and the temperature upon the expansion valve.

In order to secure the highest ideal efficiency, the working substance should be cooled before passing the expansion valve, to a temperature as nearly as possible equal to that of the supply of cooling water, and in calculating the ideal cycle of compression, it is proposed to take the temperature at which the cooling water is supplied as the temperature to which the working substance is supposed to be cooled before passing the expansion valve. It is recommended, therefore, *first*, that the ideal cycle to be adopted have a standard of compression with actual performance by the most efficient cycle employing adiabatic compression in which the pressures of suction and condensation are the same as those which occur in the actual process of working and in which the substance before passing the expansion is cooled to a temperature equal to that at which, in the actual process, the cooling water is supplied; *second*, that the pressures of suction and condensation referred to in the preceding recommendation for the actual process of working are to be the pressures measured just after and just before the substance passes the expansion valve. The committee does not consider it advisable to complicate the use of a standard cycle of compression by specifying an ideal cycle for the operation of refrigerating machines with compound action, i.e., those in which the compression or expansion takes place in two stages respectively. It was thought better that any actual machine employing such a compound process for the purpose of giving augmented efficiency should still have its performance compared with that of an ideal machine using the standard cycle.

The committee proposes to use the ratio of relative efficiency $\frac{C_a}{C_1}$, where C_1 is the coefficient of ideal performance found by dividing the heat taken in by the work expanded in the standard cycle and C_a is the coefficient of actual performance found by dividing the refrigerating effect actually produced by the work expanded in driving the compressor in the real performance of the machine. It was found by direct measurement of the refrigerating effect produced in the actual work and all the work expanded, that the work may be reckoned either as the indicated work done in the compressor or as the total work required to drive it. It is important in all systems of actual performance to state clearly which of the two methods of reckoning the work was employed and, when practicable, both the indicated work and the total work to be given, stating the results of these.

The report proceeds to the discussion of the use of the vacuum I (heat contained or enthalpy) for the expansion of the state of substance at any pressure and temperature, and appends enthropy, enthalpy through for carbonic acid, with Dr. Mollier's figures, or British units of pressure and some additions based on the recent researches of Professor Jenkins and Mr. Pye. This is followed by bibliographical references to vapor available on various substances used in refrigeration. And in conclusion, the committee recommends that the council of the Institution of Mechanical Engineers should consider the desirability of authorizing them to carry out experimental researches with the object of supplying such data as are not now available regarding the physical properties of the substances used in refrigeration.

IRON AND STEEL INSTITUTE

Advance copy, autumn section 1914

THE TRANSVERSE TESTING OF CAST IRON, George Hailstone (11 pp., 4 figs., *ec.*). The article is written with the idea of suggesting the type of cast iron test bar that should be used to obtain the most reliable and constant results with breaking load and deflection. At present, the contractor is often given an option in the specification of the test bar to be casted, viz. the bar 2 in × 1 in. section tested on 36 in. centers, or the 1 in. square bar tested on 12 in. centers. The load and deflection for each size of bar is usually stated in such cases, and it is often found that the 1 in. square bar tested on 12 in. centers is required to stand three-quarters of the load of the 2 in. × 1 in. section bar tested on 36 in. centers. The author has made a series of tests on a specially constructed testing machine, the results of which did not appear to bear out this relation. Complete data of these tests are given in tables. Indeed, the author found that the actual relation between the two English standard test bars is not 1.333 as is usually assumed, but varies only from 1.142 to 1.162 in the whole series.

To ascertain whether the skin on the test bar influences this ratio, the author made another series of tests with the bars fettled in the ordinary manner. The ratio between the two kinds of test bars was then again found to vary only from 1.134 to 1.166, or in the mean 1.146. The author comes to the conclusion that the best standard cast iron bar to give the most reliable and comparable results both in breaking load and deflection, is the one cast 2⅛ by 1⅛ in. in section 42 in. long, machined out to 2 in. by 1 in. in section and tested on 36 in. centers. The rate of testing should not exceed a load of 1 cwt. (112 pounds) in less than 15 seconds.

SCHOOL OF MINES

Quarterly, vol. 35, no. 3, April 1914, New York City.

Physical Properties of Steel and Cast-Iron Bars Broken at Different Temperatures, Harold Perrine and C. B. Spencer (abstracted)

Safe Eccentric Loading of Rivets, Joseph di Stasio

PHYSICAL PROPERTIES OF STEEL AND CAST IRON BARS BROKEN AT DIFFERENT TEMPERATURES, Harold Perrine and C. B. Spencer (19 pp., 19 plates, *he*). The article presents tests on structural metals at the temperatures which are often encountered in engineering practice. It gives a survey of previous investigations such as those of a committee of the Franklin Institute of Philadelphia, of tests made in Portsmouth dock yards, and those of Dr. Julius Kollmann, E. Howard, Fairbairn, Prof. M. Rudeloff, and Bregowsky and Spring of the laboratory of the Crane Company of Chicago.

The present investigations were carried on in the Materials Testing Laboratories of Columbia University, New York City, on apparatus designed by Prof. Ira H. Woolson. The unusual form of Rhielé testing machine of 100,000 lb. capacity was used, and the furnace to give the temperature desired was set up right in the machine. It consisted of a porcelain tube 1 ft. long and 2 in. in diameter inside, with about 25 ft. of platinum wire at ¼ in. pitch coiled around it. Fuller's earth was packed about the wire and the whole was covered with steam pipe lagging so that the entire furnace was in the form of a hollow cylinder. The temperature of the furnace was maintained by passing a current through the platinum wire and controlled quite effectively by a variable resistance placed in series with the line, permitting it being kept constant for an indefinite period. The temperature was read by a thermo-electric couple placed within the bar.

The article describes in detail the method of carrying on the experiment. The materials tested were two grades of Bessemer steel, cast iron and cast steel. The results of the tests are presented in the form of a table and a number of curves. In the case of the Bessemer steel in both grades (carbon 0.39 per cent and 0.23 per cent), the ultimate strength rose until a temperature of about 500 deg. fahr. above room temperature was reached and then it went down fairly rapidly. The elongation decreased until a temperature of about 400 deg. fahr. was reached and then it started to increase with a fair uniformity. The reduction of area in the case of the higher carbon Bessemer steel decreases until 500 deg. is reached, and in the case of the lower carbon steel, until 400 deg. fahr., then it started to rise in both cases. With cast iron a great deal of difficulty was experienced in obtaining any uniformity and it appears that the results, while accurate so far as they go, do not embrace a sufficient number of tests to determine adequately the strength of such an erratic material. The same applies to a certain extent, to the case of cast steel where the number of bars tested was insufficient. The curves tend to confirm the well-known explanation of the behavior of the metals under heat given by C. R. Roelker (*Journal of the Franklin Institute*, October 1881). Here again, it was found that the more fibrous the character of the metal, the greater is the action of heat in increasing its strength. The strength of the material is directly dependent upon the respective cohesion existing between its component molecules, and as each metal or alloy has its own definite properties and curves, this cohesion is affected by changes in temperature. Internal stresses control to a greater or less extent the shape of the curve for any particular metal alloy.

ST. LOUIS RAILWAY CLUB

Vol. 19, no. 6, October 9, 1914. St. Louis, Mo.

THE MODERN TUBE FOR LOCOMOTIVE SERVICE, P. J. Conrath (12 pp., 5 figs., *gd.*). The article contains a brief historical account and general discussion of the manufacture and properties of tubes for locomotive service. The author calls attention to the fact that soft basic open hearth steel tubes withstand the treatment encountered in the process of expanding into the flue sheet better than charcoal iron. The recent application of butt welding to safe ending has the important advantage that the metal away from the weld is not so readily overheated. In tests at the laboratories of

the Norfolk & Western Railway shops, it was found that electric butt welds have 90 per cent of the strength of the material itself. In regard to the durability of the flue sheet, some of the records are remarkable—for example, on the Lehigh Valley Railroad, an engine in fast passenger service, pulling an average 450 ton train, ran a distance of 245,675 miles in 28 months on one set of lap welded "Spellerized" steel tubes. The author also gives some information about the manufacture of hot rolled seamless tubes which appear to be more durable than cold rolled tubes. He explains this fact by mentioning that the hot method will oxidize in the air, which is beneficial to the material; for while the tubes are passing from one roll to the other, hot, they are coated with oxide, which is worked into the surface of the metal by the rolls and forms a protection to the tubes, whereas when tubes are drawn cold, all of this oxide is removed while drawing through the die and the protective layer is thus eliminated.

Miscellanea

Autogeneous Welding, Process of Keller & Knappich Company (*Die autogene Schweissung nach dem Verfahren von Keller & Knappich, Rauch und Staub,* vol. 4, no. 10, p. 158, July 1914, 2 pp., 2 figs. *d.*). The article describes a portable welding apparatus designed mainly for use on repair and installation work. The whole plant can be placed on a car and thus be easily portable. It consists essentially of an acetylene apparatus, water tank, steel tank with oxygen, and oxygen pressure reducing valve. From the illustration, it appears to be fairly compact and simple.

Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

Joseph Harrington addressed the Armour Student Branch on December 3, 1913, taking as his subject The Practical Application of the Theory of Furnace Efficiency. He dwelt in detail on each phase that makes for maximum efficiency, and touched on many points of interest to those present.

COLUMBIA UNIVERSITY

On December 5, W. T. Price, Jun.Am.Soc.M.E., gave an illustrated lecture on The Development of the Oil Engine in the United States before the Student Branch at Columbia University. He treated the design of large and small engines, and showed why some of the very successful small engines could not be built in large sizes. He discussed also the Diesel engine, widely used in Europe and comparatively new in this country. He closed with comparative figures upon the cost of purchased electric power and that obtained with the oil engine, which comparison favored the latter.

CORNELL UNIVERSITY

At a meeting of the Sibley College Student Branch held December 8, Col. E. D. Meier told briefly of some of the incidents of the trip to Germany made by the Society last summer. He spoke also of the most recent developments of the Diesel engine, particularly as used in locomotives. He said arrangements were being perfected to have a Diesel engined ship open for inspection in New York very shortly. The next day he spoke to about two hundred members of the senior class, repeating some of his talk of the previous evening, adding a discussion of the ethics of the engineering profession.

PENNSYLVANIA STATE COLLEGE

The Pennsylvania State College Student Branch held its regular monthly meeting on November 19. The program consisted of talks by H. G. Hall on Boiler Scale and the Appliances for removing it from Boiler Tubes; and A. L. Foell on Concrete, constituting the results of tests conducted at the Massachusetts Institute of Technology.

PURDUE UNIVERSITY

On November 25, Gilbert A. Young, Mem.Am.Soc.M.E., addressed a joint meeting of the LaFayette-Indianapolis Branch of the American Institute of Electrical Engineers and the Purdue University Student Section of this Society, choosing for his subject A Comparison of Engineering in Germany and America. In reality his talk was an account of his trip abroad last summer with the Society; he told of the voyage across, visits to the various universities and his impressions of German engineers and engineering.

The December 9th meeting was addressed by A. R. Nothingham, instructor in thermodynamics, who discussed his work with Professors Carpenter and Thomas, both Members of the Society, in the determination of C_p for superheated steam. He compared the elaborate apparatus used at Cornell University with that used by Knoblauch and Jacobi in Germany, and described the difficulty of drying the steam thoroughly. He described further the tests made to determine the cooling curves of superheated steam.

STATE UNIVERSITY OF IOWA

At a meeting held on December 2 of the State University of Iowa Student Branch, F. A. Richards gave a talk on the Locomobile. The main facts and data referred to were obtained from several of the recent engineering periodicals and included a description of the locomobile, its history, development and efficiency. A comparison of the amount of coal used in the locomobile per indicated horsepower with the amount used in the ordinary power plants of today concluded the lecture.

STATE UNIVERSITY OF KENTUCKY

G. B. Wurst, local forecaster for the United States Weather Bureau Department, addressed the Student Branch of the State University of Kentucky on November 13. In his introduction Mr. Wurst pointed out clearly and forcibly the advantages an engineer possessed who had a knowledge of the causes and effects of weather conditions. After a brief description of the apparatus for obtaining weather data and the principles underlying the laying out of weather maps, the members were invited to inspect the various instruments and to note especially the accuracy required in their construction. The electrical recording devices were found to be of particular interest.

STEVENS INSTITUTE OF TECHNOLOGY

The entire student body and many of the faculty attended the meeting of the Stevens Engineering Society held November 25. Calvin W. Rice, Secretary of the Society, told of the reception the Society had while in Germany last summer as the guest of the Verein deutscher Ingenieure. The speaker of the evening, Miller Reese Hutchinson, Mem.Am.Soc.M.E., was then introduced by Alex. C. Humphreys, Past-President of the Society, and he chose for his topic the Products of the Edison Laboratory.

SYRACUSE UNIVERSITY

The Syracuse University Student Branch has adopted the policy of having each member of the society prepare a short paper on some topic with which he is familiar, and inaugurated the plan at its meeting of December 5, when C. C. Keesler gave a paper on Efficiency as Applied to Shop Methods. He discussed three methods of obtaining this efficiency and in conclusion gave a brief summary of the methods employed by Mr. Taylor along these lines.

UNIVERSITY OF CALIFORNIA

A meeting of the University of California Student Branch was held December 2 and three papers were read as follows: Manufacture of Gas from Petroleum as practised in California, W. W. Penniman; Manufacture of Water Gas as practised in New York, R. S. Tom; High-Pressure Fire System of San Francisco, C. A. Rosen.

UNIVERSITY OF KANSAS

The University of Kansas Student Branch held a meeting on December 4. The papers were on the subjects of The Los Angeles Water Supply Aqueduct, by W. J. Malcolmson; and the Use of Nitrogen-Filled Incandescent Lights, by John Hartman.

UNIVERSITY OF MAINE

F. B. Slocum of the Continental Iron Works, Brooklyn, N. Y., spoke before the University of Maine Student Branch, November 25, on Internal Furnace Boilers. The author treated the development of this type of boiler and enumerated its advantages over the externally fired boiler; he gave also a detailed account of the Morrison Suspension Furnace. In part he said the internally fired boiler was used altogether on shipboard and was becoming recognized as better than externally fired boilers on land, owing to the fact that a brick setting was not required. These settings were a source of much trouble because cracks formed in them which allowed air leakage and the results were therefore inefficient. In 30,000 internally fired boilers in use in this country there was not a single record of a fatal explosion. This was due largely to the fact that the flames did not come in direct contact with the boiler shell. The firebox and ashpit were entirely surrounded by water, thus preventing the furnace from burning out. The Morrison Suspension Furnace was developed for internal furnace boilers especially. It was built of corrugated steel set into the boiler. Such a furnace was stronger than a plain one, and had an added advantage:

as the water heated, the top of the furnace expanded and contracted, and any scale that might be formed was loosened and removed by the movement of the water in the boiler.

Mr. Slocum also spoke of the construction in the Continental works of the famous *Monitor* and many other "ironclads."

UNIVERSITY OF MISSOURI

The University of Missouri Student Branch held a meeting on November 17 and Sidney Levy was the speaker of the evening. His talk was on Some of the Good and Bad Points of the Present Automobile.

UNIVERSITY OF NEBRASKA

Prof. H. H. Norris of Cornell University spoke before a special meeting of the University of Nebraska Student Branch, December 2, on the subject of Prime Movers. His talk was intensely interesting to those present for he described several of the large installations in the East which he had personally witnessed.

UNIVERSITY OF WISCONSIN

On December 4, the University of Wisconsin Student Branch held a meeting when C. D. Sperry gave a talk on a New Type of Car to be driven by Magnetic Propulsion. The car was designed to replace the carriages used in pneumatic tubes. L. V. Cowin outlined the development of different types of speedometers and tachometers now being manufactured.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The published list of "men available" is made up from members of the Society. Further information will be sent upon application.

POSITIONS AVAILABLE

1120 Mechanical engineer, who has had practical experience in power plant work and construction, to take charge of approving and checking field drawings for the installation of Taylor stokers. Salary to start $1500 to $1800.

1203 Thorough mechanic familiar with both alternating and direct-current practice, capable of taking responsible charge of the repair shops, water and steam power equipment, of a large textile plant situated in Connecticut. Position would be that of assistant to the master mechanic, and to the right man would eventually lead to position of master mechanic. State age, experience, references and compensation expected. Apply through the Society.

1206 A man with some manufacturing experience and familiar with sales work, to take charge of an office in a manufacturing concern just outside of New York City. Possibilities good and position offers an excellent opportunity to the right man. Desire technically trained man about 30 to 35 years of age.

1209 Company building line of high-grade centrifugal pumps is about to open sales agencies on a commission basis in principal cities of the United States and Canada. Communications invited from sales engineers who are open for such a proposition. Apply through the Society.

1220 Cost man for an electrical apparatus manufacturing company in Albany; should have at least three or four years' experience in cost work.

1221 Cost man for moving picture machine concern in New York; prefer man with two or three years' experience in cost work.

1223 Member holding patents on dispensing device and carbonating machine, desires to come in contact with manufacturing concern that will place these patents on the market; the inventions are original and highly thought of by engineers. Apply through the Society.

1224 Two draftsmen, design of construction dump cars. Salary $15 to $18 a week.

1225 One or two draftsmen wanted; experienced men not filled with inventive ideas but capable of serving as "gang bosses" in drafting room. Experience in engine work, particularly internal combustion engines. Apply through the Society.

MEN AVAILABLE

1 Member; age 35; technical graduate; successful record of 13 years as engineer and manager; has had entire charge of design and construction of large industrial plants, and reorganization. Good manager and systematizer; wants position near New York. Can show record of work done.

2 Junior Member; age 25; graduate mechanical engineer, experienced as factory inspector; desires position with chance for advancement; can give best of references; at present employed.

3 Member; mechanical engineer; graduate Massachusetts Institute of Technology; now holding position as engineer and factory manager, desires change to position of greater opportunities; 14 years' experience in automobile industry, successfully holding positions as designing engineer on pleasure cars and trucks, and various factory positions up to and including factory manager, employing 1800 men; good executive, with ability to reduce cost in design and manufacture.

4 Member; mechanical engineer of large experience on various machinery and machine tools; would like to make arrangement with reputable concern as engineering or sales representative; 20 years' practical experience, salesman, shop, designer, and engineer.

5 Member; position as works manager or general superintendent; experienced in manufacturing shoe machinery, typewriters, firearms, and automobiles; familiar with the latest methods of scientific management and fully competent to organize all departments where increased production at a reduced cost is the chief object.

6 Junior Member; age 34; technical graduate; 15 years' experience as machinist, draftsman, erecting and operating engineer with firms building and operating gas, steam-engines, and pumping machinery; desires position in shop or drawing room.

7 Junior Member; graduate Ohio State University; five years' experience with large firms in design, erection, and operation of steam-power plants; experienced in design of structural work and refrigeration; desires permanent connection with firm making a specialty of design and construction of industrial plants; age 28; married.

8 Member since 1882; graduate of the machine shop and engine room and up to $6000 salary; 15 years' experience as engineer and sales office manager; thoroughly informed on steam prime movers and steam appliances. Getting too old for construction work and great responsibility and would like position in sales office in New York City where services can be used to advantage.

9 Member; desires position as works manager, superintendent, or engineer; competent to organize all departments of manufacturing plant along modern lines; expert on developing new inventions; long experience; best references.

10 Member; mechanical engineer; at present engaged; desires position as manager, superintendent, or special organizer. Thoroughly practical mechanic with good technical education; good executive, organizer, and production or industrial engineer; splendid experience with good results; thoroughly conversant with and experienced in best principles and methods of efficient management; good common sense; good judgment.

11 Graduate mechanical engineer, age 27, married; three years' experience with large construction firm, three years' experience in mechanical and engineering departments of

large industrial plant. Desires to locate in East. At present employed.

12 Technical mechanical engineer; 13 years' experience operating large plants, advertising manager, sales engineer, assistant manager and general manager of large companies engaged in engineering work; would like New York agency for progressive company with well paying mechanical line; or developing, manufacturing and selling meritorious mechanical line; or would consider taking an interest in an existing firm or forming a new firm of either consulting or contracting engineers.

13 Member; consulting engineer; desires the representation of first-class firms for the District of Columbia.

14 Member; graduate mechanical engineer with wide experience in gas and oil engine design, thoroughly acquainted with latest practice, is prepared to introduce complete line of Diesel oil engines of proven merit, which can be manufactured at a low cost. Applicant desires to make connection, preferably on a partnership basis, with responsible manufacturing concern or party willing to take up manufacture of oil engines on broad business policies.

15 Member; age 42; desires position as assistant manager or general superintendent; practical mechanic; wide experience in office, stores, and shop in the manufacture of internal-combustion engines, stationary and tractor, marine engines, pumps, mining machinery, steam and locomotive work, electrical apparatus; design and erection shop and foundry buildings, steam, electric, pneumatic and hydraulic power plants. Competent to assume full charge.

16 Member; mechanical engineer; having duties calling him to Paris, will assume additional duties of an engineering or commercial nature for any one wishing to avail themselves of the services of a representative in France during February and March.

17 Associate-Member; graduate mechanical engineering from Cornell, having seven years' experience in the design, construction, operation, and testing of large steam power stations, desires position that offers a promising future. At present employed.

18 Member; technical graduate, 31 years of age, desires position as works manager, mechanical superintendent or efficiency expert with company of consulting engineers or large manufacturing corporation; extensive training and experience in central power station work, designing, purchasing, superintending construction and operating departments; consulting engineering work on large properties; power production investigations; cost reduction; experienced in mill and reinforced concrete construction work; at present employed and desires a change for advancement.

19 Mechanical engineer, technical graduate, married, desires a position as master mechanic's assistant; experienced in design, installation, inspection, repair, and other general mechanical work with a very large industrial concern; a good executive and manager of men; at present employed, but desires similar position with better opportunities. Location immaterial.

20 Associate member; age 39; technical graduate of high grade institution, wishes executive or administrative position of responsibility; now employed in charge of construction work; wide practical experience has included mechanical and electrical shop work, drafting, and design. Responsible charge of various classes of construction work in concrete, steel, brick, etc., correspondence, reports, purchasing, etc.

21 Member; wishes to connect with some reliable firm with a high standing, where the services of a high grade executive and engineer are needed to increase production by systematizing general shop practice and the design of up to date tools, etc. A practical and technical man well versed in interchangeable manufacturing, including die casting practice and automatic machinery of every description.

22 Chief-engineer, works manager, designer, wide experience in iron works, charge of production development and standardization of manufacturing; methods and efficiency systems; supervision of testing from raw material to complete machinery; mechanical and electrical operation of plants; specialty hoisting machinery.

23 Graduate Stevens '97, member of Society; broad experience including machine shop practice, superintendence of construction, field work, tests of prime movers, boilers, and power house design. For many years connected with leading consulting engineers and contractors in New York City as designing engineer and draftsman. Desires position of similar nature with engineering firm.

24 Member, wide experience in various responsible capacities, wants position as assistant to works manager where it is desired that the applicant must be a practical mechanical engineer with general experience in shop and mill practice, and capable of successfully designing special machines for own use or standard machines for regular line of competitive manufacture. Capable of supervising and responsible for the work of the engineering, cost and production departments. At present employed, married, salary $250 per month. Any location.

25 Junior member, age 26, five years experience in designing of automatic machinery, desires a position as assistant to consulting engineer, with view of taking interest in business in about a year's time; exceptional record, would prefer to locate in the east. At present employed.

26 Metallurgical engineer, 29 years of age, broad experience designing and superintending the erection of mill buildings, furnaces and machinery. Salary $2,500.

27 Member, experienced as general or business manager, salesman and executive, desires position with manufacturing concern or branch house, has tact and business ability with many years experience as sales engineer. Broad acquaintance in the engineering, contracting and manufacturing field.

28 Member, with established office in New York City wants to represent reliable manufacturing concern.

29 Stevens graduate, practical minded and ambitious, age 29, with eight years office and field experience, desires position of trust with a future.

30 Electrical and mechanical engineer and designer desires position as assistant to chief engineer or position with similar responsibility; age 27 years; of good technical education and seven years practical experience.

31 Sales engineer, experienced in handling high-grade specialties in power transmission and machinery lines; known to machinery and supply trade of United States and Canada for past eight years.

33 Commercial engineer has had responsible charge of sales and erection of suction gas producers, engines and power pumps, competent as office executive, and in publicity and purchasing work.

ACCESSIONS TO THE LIBRARY

WITH COMMENTS BY THE LIBRARIAN

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary Am. Soc. M. E.

AMERICAN INSTITUTE OF CONSULTING ENGINEERS. The Status and Professional Relations of the Engineer. *New York.* Gift of the institute.

L'ANATOMIE DE LA VOITURE AUTOMOBILE, F. Carlès. *Paris, 1913.*

CARBURATION IN THEORY AND PRACTICE, R. W. A. Brewer. *London, 1913.*

DESIGN OF SURFACE COMBUSTION APPLIANCES, C. E. Lucke. Gift of the author.

DETROIT (MICH.) BOARD OF WATER COMMISSIONERS. Sixty-first annual report, 1913. *Detroit, 1913.* Gift of the board.

DIESEL ENGINE PUMPING STATION AT THE GLADSTONE DOCK,

LIVERPOOL. Reprinted from *Engineering*, 1913. Gift of W. R. Haynie.

DER DIESELMYTHUS, T. Lüders. *Berlin, 1913.* Gift of M. Krayn.

FARM GAS ENGINES, C. F. Hirshfeld and T. C. Ulbricht. *New York, 1913.*

GUIDE TO SANITARY INSPECTIONS, W. P. Gerhard. *New York, 1909.*

HANDBOOK FOR MACHINE DESIGNERS AND DRAFTSMEN, F. A. Halsey. *New York, 1913.*

HIGHWAY ENGINEERING. TEXTBOOK ON, A. H. Blanchard and H. B. Drowne. *New York, 1913.*

INTERNATIONAL RAILWAY GENERAL FOREMEN'S ASSOCIATION. Report of proceedings of the ninth annual convention, 1913. *Winona, Minn., 1913.* Gift of the association.

MECHANICAL REFRIGERATION. A treatise for technical students and engineers, H. J. Macintire. *New York, J. Wiley & Sons, 1914.*

Professor Macintire, Mem.Am.Soc.M.E., is in the University of Washington faculty. The work is the most complete American publication on the subject, and includes chapters on testing, applications and economics. In the appendix are model specifications and many useful tables.

MODERN BATHS AND BATH HOUSES, W. P. Gerhard. *New York, 1908.*

DAS MOTORBOOT UND SEINE MASCHINELLE EINRICHTUNG, H. Haeder. *Weisbaden, 1913.*

NATIONAL CONSERVATION CONGRESS. Addresses and Proceedings, 1st, 2d, 4th, 1909, 1910, 1912. Gift of Calvin W. Rice.

NEW ENGINEERING BUILDINGS AT MINNESOTA, F. C. Shenehon. Gift of University of Minnesota.

NEW JERSEY. BOARD OF PUBLIC UTILITY COMMISSIONERS. Reports, vol. 1, May 1911-June 1913. *Trenton, 1913.* Gift of Charles A. Mead.

OLD-TIME TELEGRAPHERS AND HISTORICAL ASSOCIATION. Thirty-second annual reunion, 1913. Gift of the association.

PHILADELPHIA. TRANSIT COMMISSIONER. Report, vols. 1-2, July 1913. Gift of Ford, Bacon & Davis.

QUEENSLAND. ENGINEER FOR HARBORS AND RIVERS. Report for the year ended June 30, 1913. *Brisbane, 1913.* Gift of Department of Harbors and Rivers.

RAILROAD AND ENGINEERING JOURNAL. vol. 64-66. *New York, 1890-1892.*

REINFORCED CONCRETE, A. W. Buel and C. S. Hill. ed. 2. *New York, 1906.*

SAFEGUARDS FOR THE PREVENTION OF INDUSTRIAL ACCIDENTS. Edited by David Van Schaack. ed. 2. *Hartford, Aetna Life Insurance Co., 1913.*

SANITATION, WATER SUPPLY AND SEWAGE DISPOSAL OF COUNTRY HOUSES, W. P. Gerhard. *New York, 1909.*

SANITATION OF PUBLIC BUILDINGS, W. P. Gerhard. *New York, 1907.*

SOCIETY OF AUTOMOBILE ENGINEERS. Trans., vol. 7, pt. 2; vol. 8, pt. 1. *New York, 1912-1913.* Gift of the society.

STATIONARY ENGINEERS' BOOK, 1910-1911. Compiled by C. F. Owen. *Milwaukee, Wisconsin, Directory Co.*

SUBMARINE ENGINEERING OF TO-DAY, C. W. Domville-Fife. *London, 1914.*

TEXTBOOK ON TRADE WASTE WATERS: THEIR NATURE AND DISPOSAL, H. M. Wilson and H. T. Calvert. *London, 1913.*

THEATRE FIRES AND PANICS: THEIR CAUSES AND PREVENTION, W. P. Gerhard. *New York, 1896.*

TRAVELING ENGINEERS' ASSOCIATION. Proceedings of twenty-first annual convention, 1912. *Buffalo, 1913.* Gift of the association.

UTAH CONSERVATION COMMISSION. First biennial report, 1913. *Salt Lake City, 1913.* Gift of the commission.

PLANE AND SOLID GEOMETRY, W. B. Ford and Charles Ammerman. Edited by E. R. Hedrick. *New York, 1913.*

An elementary textbook for school use. It is based on the recommendations of the Committee of Fifteen of the National Education Association, 1911.

VECTORIAL MECHANICS, L. Silberstein. *London, Macmillan & Co., 1913.*

A well written little volume presenting the chief principles and theorems of theoretical mechanics in the language of vectors. After discussing certain special principles, such as the principles of vis viva, of center of gravity, which the author considers synonymous with that of center of mass, and the principle of areas, the author passes to the consideration of rigid dynamics, mechanics of deformable bodies and hydrodynamics. Certain parts, for example, that referring to the treatment of the Nabla, are particularly well written, and the book in general will be useful to those who wish to become acquainted with this new method of mathematical analysis without having much time to devote to it. Whether vectorial analysis is of material importance to the mechanical engineer is as yet a question. Lord Kelvin, in the sixties, refused to admit quaternions into the Treatise on Natural Philosophy unless P. G. Tait, who insisted on doing so, would show him that there is one theorem of mechanics that could be solved by vectors better than by classical mathematical methods. Since then vectorial analysis has rendered valuable services in several branches of engineering, e.g., in alternating currents, but, as far as mechanical engineering is concerned, the present work is interesting in that it does not contain a single proposition that could not be proved by Cartesian methods. L. G.

WATER SUPPLY, SEWERAGE AND PLUMBING OF MODERN CITY BUILDINGS, W. P. Gerhard. *New York, 1910.*

WENTWORTH INSTITUTE. Catalogue, 1913-14. *Boston, 1913.*

EXCHANGES

AMERICAN SOCIETY OF CIVIL ENGINEERS. Trans., vol. 76. *New York, 1913.*

CANADIAN SOCIETY OF CIVIL ENGINEERS. Charter, By-Laws and List of Members, 1913. *Montreal, 1913.*

INSTITUTION OF MECHANICAL ENGINEERS. Proc., 1913, pts. 1-2. *London, 1913.*

TRADE CATALOGUES

BOSTWICK STEEL LATH CO., *Niles, Ohio.* "Stucco" on truss loop metal lath, 15 pp.

BRISTOL CO., *Waterbury, Conn.* Cat. 1400, electric pyrometers, September 1913.

ELECTRIC TACHOMETER CO., *Philadelphia, Pa.* Bull. 100, Hopkins electric tachometers, April 1913.

HENDEE MFG. CO., *Springfield, Mass.* Indian motorcycles, 1914, 28 pp.

LENT MOTOR FIRE ENGINE CORPORATION, *New York.* Automobile fire engines, how the demand therefor is met, 8 pp.

LUNKENHEIMER CO., *Cincinnati, Ohio.* Regrinding valves, 23 pp.

NORTH WESTERN EXPANDED METAL CO., *Chicago, Ill.* Expanded metal construction, November 1913.

SANGAMO ELECTRIC CO., *Springfield, Ill.* Bull. no. 36, ampere-hour meters for general service, October 1913.

SYKES METAL LATH AND ROOFING CO., *Niles, Ohio.* Sykes expanded cup lath.

UNDER-FEED STOKER CO. OF AMERICA, *Chicago, Ill.* Publicity magazine, November 1913.

VULCAN CRUCIBLE STEEL CO., *Aliquippa, Pa.* Cat. no. 5, manufacture of high-grade crucible tool and special steel.

UNITED ENGINEERING SOCIETY

ADDRESS BY JUDGE JOHN A. STOUGHTON BEFORE THE NAVY LEAGUE, U. S. Convention, at Hotel Willard, Washington, D. C., February 22, 1912. Gift of W. J. Andrews.

JOHN FITCH. The first in the world's history to invent and apply steam propulsion of vessels through water. *1912.* Gift of F. B. Allen.

HARMSWORTH ATLAS AND GAZETTEER. *London.*

INTERNATIONAL DIRECTORY OF BOOKSELLERS AND BIBLIOPHILE'S MANUAL. Edited by James Clegg. *1914.*

PASSAIC PUBLIC LIBRARY. Twenty-fifth report, 1913. Gift of the library.

WASHINGTON ACADEMY OF SCIENCES. Proc., vols. 1-13. *Washington, 1899-1911.* Gift of Chas. L. Parsons.

PULVERIZED COAL

LIST OF REFERENCES COMPILED BY HELEN M. CRAIG, REFERENCE LIBRARIAN, ENGINEERING SOCIETIES LIBRARY

USE OF PULVERIZED COAL IN METALLURGICAL FURNACES, James Lord. *Engineers Society of Western Pennsylvania, Proc.*, October 1913, p. 363-371; discussion, p. 371-417. With bibliography.

PULVERIZED FUEL FOR BOILER FIRING, C. H. Wright. *Electrical World*, March 15, 1913, p. 567-569.

PULVERIZED COAL AS A FUEL, H. R. Barnhurst. *Metallurgical and Chemical Engineering*, March 1913, p. 127-129. With special reference to metallurgical furnaces.

POWDERED COAL AS FUEL. *Indian Engineering*, August 16, 1913, p. 91. Briefly discusses its use as a locomotive fuel.

POWDERED FUEL FOR LOCOMOTIVES, Walter D. Wood. *Railway Age Gazette*, July 4, 1913.

PULVERIZED COAL AS A CHEAP FUEL. *Automobile*, June 5, 1913, p. 1177. Letter asking questions as to the use of pulverized coal. Answers are given.

PROBLEM OF BURNING PULVERIZED FUEL, Sterling H. Bunnell. *Iron Age*, September 18, 1913, p. 618.

USE OF PULVERIZED COAL AS FUEL FOR METALLURGICAL FURNACES, H. R. Barnhurst. *American Institute of Mining Engineers, Bull.*, October 1913, p. 2523-2532.

PULVERIZED COAL AS A FUEL, A. W. Raymond. *Metallurgical and Chemical Engineering*, February 1913, p. 108-109. On the use of pulverized coal in metallurgical furnaces and in cement burning.

BURNING OF POWDERED COAL, W. E. Porter. *Industrial World*, vol. 47, p. 146-147, February 3, 1913.

POWDERED COAL AS FUEL, W. S. Quigley. *Railway and Engineering Review*, November 15, 1913, p. 1067-1068. Paper read before the American Foundrymen's Association.

SMALL COAL AND DUST: ITS PRODUCTION, PREVENTION, TREATMENT, AND UTILIZATION, WITH SPECIAL REFERENCE TO DRY MINES, J. Drummond Paton. *Institution of Mining Engineers, Trans.*, vol. 45, pt. 3, p. 421-446; discussion, p. 446-449, 1912-1913. Same in *Manchester Geological and Mining Society, Trans.*, vol. 33, pt. 6, p. 198-223; discussion, p. 223-226, 1912-1913. Results of official tests made by the Stirling Boiler Co.

FIRING SOFT COAL SCREENINGS, John S. Leese. *Mechanical World*, vol. 51, p. 160-161, 1912.

DUST FUEL BOILER AND ITS USES, H. V. Hart Davis. *Manchester Geological and Mining Society, Trans.*, vol. 22, p. 224-233; discussion, p. 233-242, 1912. Abstract in *Iron and Coal Trades Review*, February 23, 1912, p. 298-299; *Engineering Magazine*, March 1913, p. 936-938.

PULVERIZED COAL AN ECONOMICAL STEAM FUEL. *Steam*, May 1912, p. 135-138. A table shows results obtained with a Bettington boiler.

METHODS OF BURNING ANTHRACITE COAL DUST, Wm. Kavanagh. *Electrical World*, December 7, 1912.

RECENT IMPROVEMENTS AND ADDITIONS TO THE SMELTING PLANT OF THE CANADIAN COPPER COMPANY, D. H. Browne. *Canadian Mining Institute, Trans.*, vol. 15, p. 115-122, 1912.

COMBUSTION OF PULVERIZED COAL, L. S. Hughes. *American Institute of Chemical Engineers, Trans.*, vol. 4, p. 347-349, 1911.

PULVERIZED COAL, A NEW FUEL, Wm. D. Ennis. *Automobile*, vol. 25, p. 620-621, 1911. Contains paragraph on the use of powdered coal under steam boilers.

BETTINGTON BOILERS FOR PULVERIZED FUEL. *Railway News*, vol. 96, p. 1422-1423, 1911. Gives results of tests.

DE L'EMPLOI DES POUSSIERS DANS LES FOYERS MÉCANIQUES, J. Izart. *L'Electricien*, vol. 41, p. 54-57, 1911.

FIRING BOILERS WITH PULVERIZED COAL, W. S. Worth. *Power*, vol. 33, p. 264-267, 1911. Tests were made at the Henry Phipps plant, Pittsburgh.

THE ROTARY KILN, Ellis Soper. *American Society of Mechanical Engineers, Journal*, October 1910; discussion, April 1911. In the paper and in the discussion reference is made to the earliest successful use of pulverized coal for cement manufacture.

USE OF PULVERIZED COAL FOR FOUNDRY PURPOSES, Richard K. Meade. *American Foundrymen's Association, Trans.*, vol. 18, p. 39-45, 1909. Abstract in *Foundry*, vol. 34, p. 196-198, 1909. The author gives an estimate of the cost of pulverizing.

COAL DUST FIRING OF REVERBERATORY FURNACES, Edward G. Thomas. *Engineering and Mining Journal*, vol. 85, p. 269-270, 1908.

COAL DUST FIRING FOR REVERBERATORY FURNACES, Charles F. Shelby. *Engineering and Mining Journal*, vol. 85, p. 541-544, 1908.

FEEDING PULVERIZED COAL TO FURNACES, R. Cederblom. *Power*, vol. 28, p. 299-300, 1908.

SOME INDUSTRIAL APPLICATIONS OF PULVERIZED COAL, W. D. Ennis. *Brooklyn Engineers' Club, Proc.*, vol. 12, p. 183-200; discussion, p. 201-217, 1908. The author discusses various methods of grinding coal and special applications such as firing of steam boilers and industrial furnaces.

PULVERIZED COAL AND ITS INDUSTRIAL APPLICATIONS, W. D. Ennis. *Engineering Magazine*, vol. 34, p. 463, 577, 1907-1908. Costs are given.

USE OF PULVERIZED FUEL FOR HEATING METALLURGICAL FURNACES, Richard K. Meade. *American Institute of Chemical Engineers*, vol. 1, p. 98-115, 1908.

USING SOFT COAL SCREENINGS. *Power*, vol. 29, p. 706, 1908.

ECONOMY OF THE LONG KILN, E. C. Soper. *American Society of Mechanical Engineers, Trans.*, vol. 29, p. 143-148; discussion, p. 149-158, 1907. In the discussion Prof. William D. Ennis gives some figures relative to the cost of pulverizing coal.

SCKWARTZKOPFF SYSTEM OF COAL DUST FIRING, P. M. Pritchard. *Liverpool Engineering Society, Trans.*, vol. 28, p. 154-165; discussion, p. 166-176, 1907. An account of tests.

DUST FUEL STOKERS AND AUXILIARY PLANT, W. R. Harrison. *Leeds University Society*, December 10, 1906.

BAENSCH-FEUERUNGEN ZUR VERFEUERUNG VON TEER, KOHL-

ENSTAUB, ETC., Wegener. *Asphaltkunde u. Teer Industrie Zeitung*, vol. 6, p. 4, 1906.

COAL PULVERIZER AND AUTOMATIC STOKER. *American Electrician*, vol. 14, p. 196-197, 1906. Description of "Ideal" fuel feeder.

POWDERED COAL FIRING FOR STEAM BOILERS, Geo. C. McFarlane. *Engineering and Mining Journal*, vol. 81, p. 901-902, 1906. Comparison of costs of hand firing and powdered coal firing.

PROBLEM OF SMOKE ABATEMENT, Wm. H. Bryan. *American Machinist*, vol. 29, pt. 2, p. 52-54, 1906. Powdered coal is compared with other fuels, as to cost, efficiency.

COAL DUST FIRING OF REVERBERATORY MATTE FURNACES. S. Severin Sörensen. *Engineering and Mining Journal*, vol. 81, p. 274-276, 1906. With diagrams of smelting results.

COAL DUST FIRING FOR STEAM BOILERS. *Engineer* (Lond.), vol. 99, p. 502-503, 1905. Gives results of tests made with the Schwartzkopff apparatus by C. E. Stromeyer, of the Manchester Steam Users' Association.

FIRING WITH COAL DUST, Eustace Carey. *Society of Chemical Industry, Jour.*, vol. 24, p. 369-371; discussion, p. 371-372, 1905. Abstract in *Engineering and Mining Journal*, vol. 80, p. 1113-1114, 1905.

UTILIZATION OF LOW-GRADE FUELS FOR STEAM GENERATION, W. Francis Goodrich. *Engineering Magazine*, vol. 30, p. 346-354, 1905.

ROAD TESTS OF BROOKS PASSENGER LOCOMOTIVES, E. A. Hitchcock. *American Society of Mechanical Engineers, Trans.*, vol. 26, p. 290-306; discussion, p. 306-311, 1905. In the discussion on pp. 310-311 the use of pulverized coal as a fuel for locomotives was considered.

COAL DUST FIRING AS APPLIED TO ANNEALING FURNACES. *Iron and Coal Trades Review*, vol. 70, p. 1999, 1905. Schwartzkopff system.

COMPARATIVE BOILER TESTS WITH ORDINARY AND PULVERIZED COAL FIRING. *Engineering Record*, vol. 49, p. 342, 1904.

BURNING POWDERED COAL, H. J. Travis. *Power*, vol. 24, p. 168-196, 271, 1904. Tests of various systems, also comparative tests of hand fired and pulverized fuel boilers.

POWDERED COAL FOR STEEL ANNEALING, H. J. Travis. *American Machinist*, vol. 27, pt. 1, p. 791-792, 1904.

USE OF PULVERIZED COAL FOR FUEL UNDER STEAM BOILERS, J. M. Sweeney. *Western Society of Engineers, Jour.*, vol. 9, p. 141-149; discussion, p. 149-160, 1904. With tables, showing evaporation secured from pulverized fuel and hand fired coal.

TEST OF PULVERIZED FUEL. *Engineer* (U. S.), vol. 41, p. 259-260, 1904. Tests were made at the plant of the International Harvester Co.

BURNING OF PULVERIZED COAL, C. O. Bartlett. *Association of Engineering Societies, Jour.*, vol. 31, p. 44-48, 1903; *Railway and Engineering Review*, vol. 43, p. 568-569, 1903; *Engineer* (U. S.), vol. 40, p. 563-564, 1903. Paper read before the Civil Engineers' Club of Cleveland. Gives estimated cost of outfit for about 40 tons per day of 10 hours.

BURNING POWDERED COAL UNDER BOILERS. *Power*, vol. 23, p. 434-437, 1903.

POWDERED FUEL. *Power*, vol. 23, p. 561, 1903. Letter by W. E. Crane.

PULVERIZED FUEL. *Engineer* (U. S.), vol. 40, p. 272-275, 1903. Costs are given and an estimate of the saving made by pulverizing the coal.

IMPROVED SYSTEM OF BURNING COAL DUST. *Engineer* (U. S.), vol. 40, p. 93-94, 1903. The Rowe system.

A ROTARY BRUSH SYSTEM OF FEEDING PULVERIZED FUEL TO FURNACES. *Engineering News*, vol. 47, p. 147, 1902. Test of Schwartzkopff system.

SYSTEM FOR BURNING COAL DUST. *American Miller*, vol. 30, p. 1006, 1902. Bartlett and Snow system.

UEBER DEN GEGENWÄRTIGEN STAND DER KOHLENSTAUBFEUERUNG, Haeussermann. *Gewerblich technischer Ratgeber*, vol. 1, p. 227-229, 1902.

BURNING COAL DUST WITHOUT SMOKE. *Iron Age*, November 6, 1902, p. 10-12.

PULVERIZED FUEL FOR POWER PLANTS, Gasche (Aero Pulverizer). *Railroad Gazette*, vol. 34, p. 466-467, 1902. Gives summary of results of boiler trials.

KESSELFEUERUNG MIT PULVERISIERTER KOHLE ("Pulverisator cyclon," "Aero-Pulverisator"). *Leipziger Monatsschrift für Textil Industrie*, vol. 17, p. 479, 1902.

A NEW SYSTEM FOR BURNING POWDERED COAL. *Engineering News*, vol. 48, p. 548, 1902. Rowe and Bender system.

THE ROWE SYSTEM OF BURNING PULVERIZED COAL. *Engineering Record*, vol. 46, p. 592, 1902.

PULVERIZED COAL BURNING IN CHICAGO. *American Electrician*, vol. 14, p. 13-14, 1902.

PULVERIZED FUEL FOR POWER PLANTS. *Railroad Gazette*, vol. 24, p. 466-467, 1902. With tables giving summary of results of boiler trials, and heat balance for dust fuel test.

KOMBINIERTE KOHLENSTAUBFEUERUNG. *Zeitschrift für Beleuchtungswesen*, vol. 7, p. 332-333, 1901.

KOHLENSTAUBFEUERUNGEN, Ruhl. *Kraft*, vol. 18, pt. 1, p. 35-37, 1901.

POWDERED FUEL FOR BOILER FURNACES AT THE ALPHA CEMENT COMPANY'S WORKS, ALPHA, N. J. *Engineering News*, vol. 45, p. 452-453, 1901.

A NEW METHOD OF BURNING POWDERED FUEL. *Engineering News*, vol. 45, p. 178-179, 1901. Description of Westlake system, with results of tests.

THE AERO SYSTEM OF PULVERIZED FUEL COMBUSTION. *Engineering Record*, vol. 43, p. 506, 1901.

PULVERIZED FUEL, R. A. Douglas. *American Electrician*, vol. 13, p. 434-435, 1901.

TWO RECENT SYSTEMS FOR BURNING POWDERED COAL. *Engineering News*, vol. 46, p. 415-416, 1901. Cyclone and Aero Pulverizer systems.

FREITAG'S KOHLENSTAUB-FEUERUNG. *Kraft*, vol. 17, p. 5-6, 1900.

BURNING OF PULVERIZED COAL. *Engineering Record*, vol. 42, p. 241-242, 1900. Editorial note on the use of pulverized coal in rotary cement kilns.

BURNING PULVERIZED COAL. *Railway and Engineering Review*, vol. 40, p. 560-562, 1900.

BURNING POWDERED COAL IN STATIONARY BOILERS. *Engineering Record*, vol. 42, p. 615-616, 1900. Tests with Westlake apparatus.

EMPLOI DU CHARBON PULVÉRISÉ DANS LES FOYERS DES CHAUDIÈRES ET DES FOURS MÉTALLURGIQUE (système Schwartzkopff), A. Halleux. *Revue Universelle des Mines*, vol. 46, p. 21-34, 1899.

KOHLENSTAUBFEUERUNGEN (Zusammenstellung der verschiedenen Erfindungen und Patente). *Schweizerische Bauzeitung*, vol. 34, p. 4-6, 1899.

USE OF COAL DUST AS FUEL FOR BOILERS, Count Caracristi. *Iron and Coal Trades Review*, vol. 58, p. 643, 1899.

DIE FREITAGSCHE KOHLENSTAUBFEUERUNG, L. Kaufmann. *Zeitschrift des Vereines deutscher Ingenieure*, vol. 43, p. 988-992, 1899.

THE UTILIZATION OF COAL SLUDGE AND COAL DUST. *Colliery Guardian*, vol. 77, p. 477, 1899. Abstract from *Neues Saarbrueckener Gewerbeblatt*.

FREITAG APPARATUS FOR COAL DUST FUEL. *Colliery Guardian*, vol. 78, p. 542-543, 1899. Abstract of article by L. Kaufmann in *Zeitschrift des Vereines deutscher Ingenieure*.

BURNING LOW-PRICED FUEL, W. H. Wakeman. *American Machinist*, vol. 22, p. 101, 1899.

UEBER VERWERTHUNG VON KOHLENSCHLAMM UND KOHLENSTAUB. *Oest. Zeitschrift für Berg u. Hüttenwesen*, vol. 57, p. 127-129, 1899. Abstract in *Institution of Civil Engineers, Proc.*, vol. 136, p. 421-422, 1898-1899.

CHAUFFAGE DES CHAUDIÈRES AU CHARBON PULVÉRISÉ (système F. Forst). *Revue Industrielle*, vol. 29, p. 16, 1898.

NEW COAL DUST FURNACES. *Iron and Coal Trades Review*, vol. 47, p. 177-178, 1898. Pinther, Russell, Lester & Ernst, Peck and Patterson systems.

VERSUCHSERGEBNISSE DER DE CAMPSCHEN KOHLENSTAUBFEUERUNGEN, Schneider. *Mitteilungen aus der Praxis des Dampfkessel und Dampfmaschinenbetriebes*, vol. 20, p. 76, 1897.

NOVELTIES IN COALDUST FIRING APPARATUS. *Colliery Guardian*, vol. 76, p. 514, 1898. Abstract from *Tonindustrie Zeitung*.

RUHE'S APPARATUS FOR BURNING POWDERED COAL. *Engineering* (Lond.), vol. 63, p. 72, 1897.

BURNING POWDERED COAL UNDER STEAM BOILERS. *Engineering News*, vol. 38, p. 189-190, 1897. Wegener system.

NEUERUNGEN AN KOHLENSTAUBFEUERUNGEN. *Dinglers Polytechnische Journal*, vol. 305, p. 272-276, 1897.

CHAUFFAGE AU PULVÉRIN DE CHARBON, Vacquiers. *La Vie Scientifique*, 1897, pt. 1, p. 253-254.

CHAUFFAGE DES CHAUDIÈRES AU CHARBON PULVERISE, P. Chevillard. *Revue Industrielle*, vol. 28, p. 162, 294, 385, 1897.

DIE VERWENDUNG DER KLEINKOHLE, Moriz Caspaar. *Oest. Zeitschrift für Berg u. Hüttenwesen*, vol. 45, p. 373, 401, 1897.

KOHLENSTAUBFEUERUNG UND VERMAHLUNG DER KOHLE, Warlich. *Dampf*, vol. 41, pt. 1, p. 49-51 (1897).

RUHL'S APPARATUS FOR BURNING POWDERED COAL. *Engineering*, vol. 63, p. 71-73, 1897.

FORTSCHRITTE AUF DEM GEBIET DER KOHLENSTAUBFEUERUNG, Schütze. *Dampf*, vol. 13, p. 1205, 1896.

KOHLENSTAUBFEUERUNG APPARAT, Schütze. *Uhlands Technische Rundschau*, 1896, no. 3, p. 55.

KOHLENSTAUBFEUERUNG (system Unger). *Tonindustrie Zeit.*, vol. 20, p. 861, 1896.

KOHLENSTAUBFEUERUNG NACH SYSTEM CORNELIUS (Deutsches Reich-Patent, 78, 587). *Glasers Annalen für Gewerbe und Bauwesen*, vol. 39, p. 139-140, 1896.

KOHLENSTAUBFEUERUNGEN IM DAMPFKESSELHAUSE DES KÖNIGLICHEN OPERNHAUSES IN BERLIN (Patent Ruhl). *Centralblatt der Bauverwaltung*, vol. 16, p. 59, 1896.

POWDERED COAL AS FUEL. *Marine Engineer*, vol. 17, p. 433, 1896.

ECONOMIC VALUE OF COAL DUST, W. Blakemore. *Canadian Mining Review*, vol. 15, p. 200-201, 1896. Paper read before Ontario Mining Institute.

COMBUSTION OF POWDERED COAL. *Engineering* (Lond.), vol. 61, p. 80-81, 1896. Experiments made by Mr. Bryan Donkin with the Wegener apparatus.

BERLIN INDUSTRIAL EXHIBITION. *Engineer* (Lond.), vol. 82, p. 255, 1896. Brief description of coal-dust firing exhibit.

WEGENER'S POWDERED FUEL BOILER FURNACE AND APPARATUS. *Engineer* (Lond.), vol. 81, p. 485-486, 1896. A brief account of experiments made by Mr. Bryan Donkin.

COAL DUST FIRING IN THE IRON INDUSTRY. *American Manufacturer and Iron World*, August 28, 1896, p. 300. Abstract from article by Victor von Neumann in the *Zeit. Oesterr. Ingen. u. Architekten Verein*, vol. 48, p. 342, 353, 1896. The Schwartzkopff apparatus is described.

COAL DUST FUEL. *Institution of Civil Engineers, Proc.*, vol. 123, p. 516-518, 1895-1896. Abstract of paper by C. Schneider in *Mittheilungen aus der Praxis des Dampfkessel und Dampfmaschinen Betriebes*, 1895, p. 336.

FIRING WITH COAL-DUST AND COAL GRINDING PROCESSES. *Institution of Civil Engineers, Proc.*, vol. 126, p. 473-474, 1895-1896. Abstract of article by Messrs. Zarniko and Prople in *Gesundheits-Ingenieur*, 1896, p. 210.

KOHLENSTAUBFEUERUNGEN, Ferdinand Bleichsteiner. *Oest. Zeitschrift für Berg und Hüttenwesen*, vol. 44, p. 237-240, 1896.

KOHLENSTAUBFEUERUNG, Förster. *Uhlands Technische Rundschau*, 1896, no. 3, p. 24.

KOHLENSTAUBFEUERUNGEN AUF DER BERLINER GEWERBE-AUSSTELLUNG, 1896, Schmidt. *Gesundheits-Ingenieur*, vol. 19, p. 354, 1896.

NACHTHEILE DER KOHLENSTAUBFEUERUNGEN, Schneider. *Alkohol*, vol. 6, p. 117, 1896.

KOHLENSTAUBFEUERUNGEN. *Zeit. des Vereines deutscher Ingenieure*, vol. 40, p. 432-436, 1896. Gives results of tests with different systems.

VERSUCHE MIT DEN KOHLENSTAUBFEUERUNGEN VON SCHWARTZKOPFF UND FRIEDEBERG. *Dampf*, vol. 13, p. 502.

HERSTELLUNG VON KOHLENSTAUB FÜR KOHLENSTAUBFEUERUNGEN, Friedrich. *Dampf*, vol. 13, p. 710, 1896.

APPARATOS PARA LA COMBUSTIÓN DE CARBONES MENUDOS, Colomer. *Revista Minera*, vol. 45, p. 175, 1895. Wegener, Friedeberg and Schwartzkopff systems.

DIE NEUEREN KOHLENSTAUBFEUERUNGS-APPARATE, B. Kosmann. *Stahl und Eisen*, vol. 15, p. 235-242, 1895.

DIE KOHLENSTAUBFEUERUNG, Schneider. *Zeit. des Verbandes der Dampfkessel Ueberwachungs-Vereins*, vol. 18, p. 336, 1895.

KOHLENSTAUBFEUERUNGEN, Schrey. *Glaser's Annalen für Gewerbe und Bauwesen*, vol. 36, p. 213-219; discussion, p. 219-220, 1895. Paper read before the *Verein deutscher Maschinen Ingenieure*.

KOHLENSTAUBFEUERUNGEN VON SCHWARTZKOPFF. *Oest. Zeitschrift für Berg und Hüttenwesen*, vol. 43, p. 187-188, 1895.

DIE SCHWARTZKOPFF'SCHE KOHLENSTAUB FEUERUNG, Schneider. *Zeit. Verband Dampfkessel Ueberwach, Ver.*, vol. 18, p. 403, 1895.

VERSUCHSERGEBNISSE MIT DER WEGENER'SCHEN KOHLENSTAUBFEUERUNG. *Zeit. Verband Dampfkessel Ueberwach, Ver.*, vol. 18, p. 380, 1895.

KOHLENSTAUBFEUERUNGEN. *Zeit. des Vereines deutscher Ingenieure*, vol. 39, p. 1379-1382, 1895. Abstract in *Engineer* (Lond.), vol. 81, p. 106, 1896. Gives historical sketch of the use of coal dust as fuel.

CHAUFFAGE DES CHAUDIÈRES AU CHARBON PULVÉRISÉ (Systéme Baumert et Wegener). *Revue Industrielle*, vol. 25, p. 62-63, 1894.

APPAREIL FRIEDEBERG POUR BRÛLER LA POUSSIÈRE DE CHARBON, G. Lestang. *Revue Industrielle*, vol. 25, p. 461-462, 1894.

APPARATUS FOR BURNING COAL DUST (Friedeberg system). *Industries and Iron*, vol. 17, p. 354, 1894.

STAUBKOHLENFEUERUNG (EINRICHTUNG UND VERSUCHE IN DER INKRUSTATSEINFABRIK ZU PLÖTZENSEE). *Dampf*, vol. 11, p. 102, 1894.

UEBER KOHLENSTAUBFEUERUNGEN. *Dampf*, vol. 11, p. 509, 1894.

NEUERE DAMPFKESSEL KESSELFEUERUNGEN. *Dinglers Polytechnische Journal*, vol. 291, p. 241-247, 1894.

UEBER KOHLENSTAUBFEUERUNGEN. *Dinglers Polytechnische Journal*, vol. 292, p. 265-270, 1894.

FRIEDEBERG APPARATUS FOR BURNING COAL DUST. *Industries and Iron*, Vol. 17, p. 405, 1894.

DIE KOHLENSTAUBFEUERUNG PATENTS FRIEDEBERG, B. Kosmann. *Berg u. Hüttenmannische Zeitung*, vol. 53, p. 371-374, 1894.

NEUERE KESSELFEUERUNGEN. *Dinglers Polytechnische Journal*, vol. 287, p. 108, 1893.

KOHLENSTAUBFEUERUNG VON BAUMERT UND WEGENER. *Dinglers Polytechnische Journal*, vol. 289, p. 23, 1893. Paragraph on use by the North German Lloyd Company.

MELDRUM SELF CONTAINED DUST-FUEL FURNACE, Wm. Boby. *Federated Institution of Mining Engineers, Trans.*, vol. 3, p. 250-255, 1891-1892.

STEAM BOILERS WITH FORCED BLAST: THE PERRET SYSTEM FOR BURNING DUST AND REJECTED FUELS, WITH NOTES ON TESTING BOILERS, Bryan Donkin. *Federated Institution of Mining Engineers, Trans.*, vol., 4, p. 154-166, 1892-1893. Discussion of papers by Wm. Boby and B. Donkin, p. 348-350.

RAUCHLOSE KOHLENVERBRENNUNG (MITTELST STAUBKOHLE). *Mittheilungen aus dem Gebiete des Seewesens*, vol. 21, p. 63, 1893.

FOYERS DU SYSTÈME DE MM. BAUMERT ET WEGENER POUR L'UTILISATION SOUS LES CHAUDIÈRES DE CHARBON PULVÉRISÉ. *Revue Universelle des Mines*, vol. 24, p. 238-241, 1893.

UEBER EINE NEUE FEUERUNG (PATENT KUDLICZ) ZUM VERBRENNEN VON FEINKOHLE, KOHLENLÖSCHE, SCHLAMMKOHLE, KOKSKLEIN, BRAUNKOHLENABFÄLLEN UND DERGL, L. Glaser. *Glasers Annalen für Gewerbe und Bauwesen*, vol. 33, p. 31-37, 1893.

ON SOME APPLIANCES FOR THE UTILIZATION OF REFUSE AND DUST FUEL, Walter G. McMillan. *Society of Arts, Journal*, vol. 34, p. 527-540; discussion, p. 540-542, 1886. Various furnaces are described, and results of tests with Perret's boiler furnace are given.

POWDERED ANTHRACITE AND GAS FUEL. *Engineering News*, vol. 16, p. 314-315, 1886. Abstract from report of Scranton Board of Trade.

PERRET'S FURNACE FOR DUST FUEL. *Iron Age*, December 10, 1885, p. 35.

ON THE CONVERSION OF HEAT INTO USEFUL WORK, William Anderson. *Society of Arts, Journal*, vol. 33, p. 643-656, 1885. The author describes Crampton's system of coal dust burning for a revolving puddling furnace, also the same system adapted to marine boilers.

THE UTILIZATION OF COAL DUST AS FUEL. *Engineering News*, vol. 10, p. 163, 1883.

COAL DUST FUEL. *Engineer* (Lond.), vol. 43, p. 335-336, 1877. Gives results of experiments with Stevenson's apparatus.

ON THE USE OF PULVERIZED FUEL, B. F. Isherwood. *Engineering and Mining Journal*, vol. 21, p. 12, 31, 57, 104, 129, 1876. An account of experiments made at South Boston, with the Whelpley and Storer apparatus. In addition, the author gives a sketch of the history of pulverized coal burning, beginning with the English patent of J. S. Dawes in 1831.

NOTES SUR LES DANGER QUE PARAÎT PRÉSENTER LA POUSSIÈRE DE HOUILLE DANS LES MINES, MÊME EN L'ABSENCE DE GRISON. *Annales des Mines, Mémoires*, Ser. 7, vol. 7, p. 176-179, 1875.

ON THE COMBUSTION OF POWDERED FUEL IN REVOLVING FURNACES, AND ITS APPLICATION TO HEATING AND PUDDLING FURNACES, T. R. Crampton. *Iron and Steel Institute, Journal*, 1873, p. 91-101; discussion, p. 101-107.

ON THE USE OF PULVERIZED FUEL, Lieut. C. E. Dutton. *Franklin Institute, Journal*, vol. 81, p. 377; vol. 92, p. 17, 1871. Whelpley and Storer process.

FOUR CRAMPTON, M. Lavalley. *Société des Ingénieurs Civils de France, Mémoires*, 1875, p. 266-272; discussion, p. 272-278.

BOOKS AND PAMPHLETS

BARR, WILLIAM M. A Practical Treatise on the Combustion of Coal, including descriptions of various mechanical devices for the economic generation of heat by the combustion of fuel, whether solid, liquid or gaseous. *Indianapolis, John Bros., 1879.* Chapter 14—Coal dust fuel. An account of experiments made by the U. S. Government in 1876. Comparative economy of powdered fuel as compared with ordinary coal. Stevenson's apparatus for burning coal-dust.

BERTIN, L. E. Marine Boilers. Translated and edited by Leslie S. Robertson. Ed. 2. *New York, Van Nostrand, 1906*, p. 114-120.

BOURNE, JOHN. A Treatise on the Steam Engine. *New York, Appleton, 1866*, p. 358. The author considers that coal-dust burning in locomotives would be feasible, but details had not been worked out.

CLARK, D. KINNEAR, editor. Fuel: its combustion and economy, consisting of abridgements of "Treatise on the Combustion of Coal and Prevention of Smoke," by C. W. Williams, and "The Economy of Fuel," by T. Symes Prideaux, with extensive additions on recent practice in the combustion and economy of fuel, coal, coke, wood, peat, petrolum, etc. *Lond., Crosby, Lockwood; New York, Van Nostrand, 1879.* Chapter 25—Powdered Fuel.

DAMOUR, EMILIO, AND QUENEAU, A. L. J. Industrial Furnaces. *New York, Engineering and Mining Journal, 1906*, p. 275-286. Contains list of U. S. Patents covering the stoking of powdered fuel to May 10, 1904.

FOWLER, WILLIAM H. Steam Boilers and Supplementary Appliances. *Manchester, Scientific Pub. Co.*, p. 491-492, paragraph on dust fuel stokers.

FULTON, CHARLES HERMAN. Principles of Metallurgy. *New York, McGraw-Hill Co., 1910*, p. 422-424.

GERHARDT, G. F. Steam Power Plant Engineering. Ed. 4. *New York, Wiley, 1913*, p. 58-66.

GROVES, CHARLES EDWARD, AND THORP, WILLIAM. Chemical Technology, vol. 1. Fuel and its Applications. By E. J. Mills and F. R. Rowan. *Philadelphia, Blakiston, 1889*, p. 364, 664.

HOFMAN, H. O. General Metallurgy. *New York, McGraw-Hill Book Co., 1913*, p. 183-189. Mention is made of the early attempts to utilize coal dust as fuel, beginning with Niepce in 1818. A list of references is given.

HUTTON, FREDERICK REMSEN. The Mechanical Engineering of Steam Power Plants. Ed. 3. *New York, Wiley, 1908.* Chapter 9—Firing boilers with gas or liquid hydrocarbon or with pulverized fuel.

KENT, WM. Steam Boiler Economy. *New York, Wiley, 1901*, p. 132, 183.

PÜTSCH, ALBERT. Gas and Coal Dust Firing: a critical review of the various appliances patented in Germany for this purpose since 1885; translated by Charles Salter. *London, 1901.*

THURSTON, R. H. A Manual of Steam Boilers, their design, construction and operation. *New York, Wiley, 1888*, p. 164-165. Paragraph on pulverized coal.

TURIN, ANDRÉ. Les foyers de chaudières. *Paris, Dunod & Pinat, 1913*, p. 156-161.

U. S. STEAM ENGINEERING BUREAU (NAVY DEPARTMENT). Annual Report, 1876. *Washington, Govt., 1876.* Experiments were made under the direction of B. F. Isherwood, with a horizontal fire-tube boiler, at East Boston, Mass., to test the process of Whelpley and Storer for effecting the combustion of coal-dust. The apparatus for grinding the coal was the only part of the process which was patented. The coal-dust was blown upon a bed of ignited lump coal. Tables are given, showing the comparative economy of burning lump coal alone, or lump coal with coal-dust. It was found that the use of powdered fuel was more expensive, on account of the cost of pulverization.

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Case School of Applied Science	February 14, 1913	F. H. Vose	H. C. Mummert	J. B. Whitacre
Columbia University	November 9, 1909	Chas. E. Lucke	F. B. Schmidt	H. F. Allen
Cornell University	December 4, 1908	R. C. Carpenter	J. G. Miller	D. S. Wegg, Jr.
Lehigh University	June 2, 1911	P. B. de Schweinitz	W. C. Owen	T. G. Shaffer
Leland Stanford Jr. University	March 9, 1909	W. F. Durand	C. P. Campbell	B. M. Green
Massachusetts Institute of Technology	November 9, 1909	E. F. Miller	H. W. Treat	L. L. Downing
New York University	November 9, 1909	C. E. Houghton		
Ohio State University	January 10, 1911	Wm. T. Magruder	R. H. Neilan	R. M. Powell
Pennsylvania State College	November 9, 1909	J. P. Jackson	H. L. Swift	H. L. Hughes
Polytechnic Institute of Brooklyn	March 9, 1909	W. D. Ennis	F. Peltier	A. Bielek
Purdue University	March 9, 1909	G. A. Young	A. D. Meals	G. F. Lynde
Rensselaer Polytechnic Institute	December 9, 1910	A. M. Greene, Jr.	F. E. McMullen	R. L. Manier
State University of Iowa	April 11, 1913	R. S. Wilbur	F. H. Guldner	C. S. Thompson
State University of Kentucky	January 10, 1911	F. P. Anderson	H. G. Strong	R. T. Thornton
Stevens Institute of Technology	December 4, 1908	Alex. C. Humphreys	L. F. Bayer	C. H. Colvin
Syracuse University	December 3, 1911	W. E. Ninde	G. T. Parsons	W. J. Campbell
University of Arkansas	April 12, 1910	B. N. Wilson	M. McGill	C. Bethel
University of California	February 13, 1912	Joseph N. LeConte	R. Guillon	P. H. Landon
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University of Maine	February 8, 1910	Arthur C. Jewett	E. E. Fowler	A. B. Hayes
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University of Minnesota	May 12, 1913	J. J. Flather	A. Buenger	J. A. Colvin
University of Nebraska	December 7, 1909	J. D. Hoffman	A. A. Luebs	G. W. Nigh
University of Wisconsin	November 9, 1909	H. J. Thorkelson	O. D. Smart	M. A. Cook
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Yale University	October 11, 1910	L. P. Breckenridge	L. F. Harder	M. C. Corbett

PERSONAL NOTES

Henry M. Leland, a Manager of the Society and general manager of the Cadillac Motor Car Company of Detroit, is president this year of the Society of Automobile Engineers.

At the meeting in London on December 9 of the committee of the International Association for Testing Materials, the United States was represented by Dr. Richard Moldenke and Walter Wood, Members Am.Soc.M.E. The proceedings of the meeting have not been made public, but certain proposals representing the view of American and German producers are to be circulated among British makers of pig-iron, cast-iron pipe and miscellaneous iron castings, with a view to getting a consensus of opinion.

John Price Jackson, recently dean of the School of Electrical Engineering of Pennsylvania State College and now commissioner of the department of labor and industry at Harrisburg, has been chosen one of the five engineers constituting the State Engineers Commission which is to draft a code for the registration of engineers in the State of Pennsylvania.

T. Kennard Thomson, a member of the American Committee to celebrate the 100th Anniversary of Peace among English-speaking peoples, proposes as part of the celebration the establishing of an international park and forest along the Canadian border from Lake Superior to the Pacific Ocean, having a width of ten miles in both the United States and Canada. This would act as wind break, thus greatly benefiting the climate, and a large number of animals could be bred to advantage on this 30,000 square miles of part forest, lake and stream, so that by proper management the reservation could be made not only self-supporting but a profit producer as well. Mr. Thomson's work in civil engineering is well known and his scheme for building sea walls at the lower end of Manhattan to form a new neck of land, thus relieving the congestion which now exists in lower New York, recently attracted much attention.

Wm. N. Stevens has severed his connections with the John Simmons Company, New York, to become identified with the Stevens-Aylsworth Company, of the same city.

Arthur M. Crane, who was formerly with the New York Continental Jewell Filtration Company of New York, is now sales manager of the Permutit Company of New York.

Carr L. Glasgow, until recently district manager of Allis-Chalmers-Bullock, Ltd., Montreal, Canada, has entered the service of Fairbanks, Morse & Company, New York.

Henry C. Beckwith has accepted the position of district manager of the T. L. Smith Company, Chicago, Ill. Mr. Beckwith was formerly associated with the Constructors Equipment Company of Seattle, Wash.

Aimé L. G. Fritz, formerly connected with the Toronto Electric Light Company of Toronto, Canada, has become superintendent of construction for the London Electric Company, London, Canada.

L. H. Mesker has severed his connections with the United Engineering and Construction Company, Cleveland, Ohio, to enter the sales department of the Cleveland City Forge and Iron Company.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Announcement has been made of the plans for the new buildings of the Massachusetts Institute of Technology, to be erected on the Charles River in Cambridge, Mass. These plans have been developed by the architect, William W. Bosworth, following an extended preliminary engineering investigation of college buildings throughout the world, made by John R. Freeman, Past-President of the Society, who did this work as an interested alumnus of the Institute. When completed, the buildings will comprise one of the most imposing educational groups in America, the impressiveness of which will be enhanced by the location on the Charles River.

The library is the central feature, in front of which is a central court of immense size and on two sides of which are the main sections of the educational building. Unlike the plan usually followed in this country, of separate buildings for the different departments, there will be a single large building for this purpose, with wings and open courts.

The construction features of this building are based upon a unit system of bays, the floors of which are supported by the outside walls independent of the partitions, so that rooms can be made in any multiple of the basic unit desired, simply by removing the partitions. In a similar manner the structure can be added to by building additional bays of standard size. It will be of interest to engineers to say that there will be two and one-half acres of roof-lighted drafting rooms. The size of the undertaking is indicated by the fact that there will be begun a simultaneous construction of buildings whose capacity will reach about 15,000,000 cubic feet, and it is estimated that the main central court is sufficient in size to offer a resting place for ten of the largest vessels of the United States Navy. The department of mechanical engineering will contain 176,000 square feet, that of electrical engineering 50,000 square feet, of mining engineering 77,000 square feet, and of naval engineering 35,000 square feet.

Coincident with this announcement is another one to the effect that there will be coöperation in instruction between the engineering department of Harvard University and of Massachusetts Institute of Technology, whereby students and professors may interchange. Duplication in instruction in these neighboring institutions will be avoided and the Harvard students will have the advantage of the Technology laboratories.

STEVENS TECHNOLOGY MEETING

At a convention held at Stevens Institute of Technology on January 9 there was a general discussion of the relation of public utilities to the communities in which they operate. Among those who participated were Dr. Alex. C. Humphreys, President of Stevens Institute of Technology and Past-President of the Society, John W. Lieb, Jr., manager of the New York Edison Company, and James E. Sague, a member of the New York Public Service Commission, both members of the Society.

Dr. Humphreys in the course of his remarks referred to the control of public utilities by public service commissions, expressing his belief in a proper measure of control and regulation, but pointing out the necessity for broad knowledge and efficiency on the part of the commissioners. He said in part:

"Many of the questions which these commissions are called upon to determine require for their solution the high-

est engineering training and experience. And yet it is the exception when an engineer is appointed as a commissioner. The engineering profession is most often represented not as members of the board, but as employees of these boards, and so with no vote. Frequently the engineers so employed as subordinates to the commissioners are not qualified for an authoritative position in any of the companies over which they are thus given, indirectly it is true, a large measure of authority. I have held that on every one of these commissions the engineering profession should be adequately represented in the persons of men educated in the science of engineering and later trained in the hard school of experience, these men to be voting commissioners.

I by no means claim that because a man is an engineer he is thus necessarily qualified for membership on such a board, any more than a man is qualified to be a judge because he is a lawyer. Whether the commissioner is engineer, lawyer, accountant, or business man, he should be broadly trained and he should have had experience in the exercise of administrative functions."

Mr. Lieb outlined the broad powers vested in such commissions, the immense field which their activities cover, and emphasized again the necessity for a personelle of the highest order. "It must be obvious," he said, "that the presence of a technically educated and scientifically trained member on the commission should be of enormous assistance and value in its work, only second in importance to the presence of a representative of the legal profession. The professional politician, or 'statesman,' as he would prefer to be called, is likely to be strongly represented in the make-up of the commissions, but to find a representative of the engineering profession in the Commissioner's chair is, indeed, unusual and exceptional.

Our technical graduates should be trained and train themselves so that when they are called upon for the facts, or to present evidence or testimony in these cases that their presentation be clear, convincing, to the point, and delivered with the weight of authority. We should cultivate the habit of clear statement as well as clear thinking, and school ourselves in the facility of communicating technical information and expert testimony, so that it may be understood by the layman and that our arguments and presentation may create a favorable impression and carry due weight."

Mr. Sague followed with a most interesting account of the large problems with which commissions have to deal and the vast field which they must cover in their investigations in order to keep informed and to make intelligent investigations.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

At a meeting on January 14, F. L. Brewer, Jr. gave a talk on Stanley Steam Automobiles, in which he described the entire power plant and took up the advantages and disadvantages of steam in the automobile industry. Lantern slides were used in illustrating Mr. Brewer's remarks, and a discussion followed.

CARNEGIE INSTITUTE OF TECHNOLOGY

The regular meeting of the Carnegie Branch was held on December 17. Prof. J. C. Sproul gave a talk on Modern Automobile Practice in which he described the various types of automobile motors used in this country and in Europe, giving the relative merits of each and the results that have been obtained from them in testing. He also outlined the construction and working of the various differentials and axles that have been adopted in the best automobile and traction engine practice.

COLUMBIA UNIVERSITY

H. L. Gantt, Mem.Am.Soc.M.E., gave a lecture on the Relation between Employer and Employee before the Mechanical Engineering Society of Columbia University on January 9. He pointed out that the real problem which confronts the college graduate is human nature: how to deal with men. To obtain successful cooperation with the workman, the employer must cause the workman to have an interest in his work. This can be accomplished by setting a task for him to do, showing him how to do it, and paying a good wage. As the trained man can on the average do three times as much work as one who is untrained, these methods result in increased production and lowered wage costs.

CORNELL UNIVERSITY

Prof. F. R. Hutton, Honorary Secretary Am.Soc.M.E., gave a talk before the Sibley College Student Branch on December 16, on the Relation of the Draftsman to the Engineer, in which he dealt purely with the ethical side of the relationship.

On January 15 Mr. Henderschott, director of the New York Edison Schools and secretary of the Association of Corporation Schools, spoke of the present great interest in industrial instruction, and pointed out the need of commercial training in the public schools. He gave statistics showing that in a 300-day year, of eight hours a day, one workman was killed every four minutes and another injured every four seconds each year. This proportion is being reduced by welfare work, including safety devices, sanitation and instruction.

LEHIGH UNIVERSITY

On December 9 at a meeting of the Lehigh University Mechanical Engineering Society T. G. Shaffer read a paper on Transformers, which gave a short outline of the methods of construction and of testing in transformer practice. Prof. A. W. Klein, Mem.Am.Soc.M.E., also described his trip to Germany last summer to attend the meeting of the Verein deutscher Ingenieure.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

At a meeting of the Mechanical Engineering Society of the Massachusetts Institute of Technology on December 31, Gorham Dana gave an interesting talk on the Requirements of the Underwriters for Fire Prevention. His remarks were illustrated by lantern slides.

OHIO STATE UNIVERSITY

The Student Branch of Ohio State University has held regular meetings during the term. On October 1 Prof. F. E. Sanborn, Mem.Am.Soc.M.E., gave an address on Technical Museums; on October 17 C. L. Newby spoke on the Transhipping of Cargoes on the Great Lakes; on November 8 Prof. F. W. Marquis, Jun.Am.Soc.M.E., read a paper on the Design and Construction of a Locomotive Testing Laboratory. On December 11 B. H. Smith gave an illustrated lecture on the Gas Producer, placing special emphasis on recent development, such as the static scrubber, etc.

PENNSYLVANIA STATE COLLEGE

The Pennsylvania State College Student Branch held a meeting on January 14 at which the following officers for the second semester were elected: A. L. Foell, chairman, C. F. Kennedy, vice-chairman, R. W. Hertzog, secretary, R. B. Rudy, treasurer. P. W. Barr presented a paper on

Resuscitation, and N. H. Slack a paper on the Advancement in Motor Car Design for 1914.

POLYTECHNIC INSTITUTE OF BROOKLYN

On January 10, Franklin Van Winkle, associate editor of Power, spoke before the Polytechnic Institute of Brooklyn Student Branch on Hydroelectric Development at Paterson, N. J. Much descriptive material was given, illustrated by lantern slides, which plainly showed how these plants were at present inadequate where natural power was used.

RENSSELAER POLYTECHNIC INSTITUTE

In celebration of the ninetieth birthday of Rensselaer Polytechnic Institute a dinner will be given on Friday evening, February 6, at the Hotel Biltmore, New York City, at which the guests of honor will be the presidents of the American Society of Civil Engineers, The American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the American Institute of Mining Engineers, and the Society of Naval Architects and Marine Engineers, and other distinguished engineers and representative men identified with engineering development. There will be addresses by men of national reputation, who can speak with authority upon the value of engineering service and upon the opportunities, responsibilities and obligations of engineers in this era of progress and development. The members of The American Society of Mechanical Engineers are invited to attend. E. N. Sanderson, Mem.Am.Soc.M.E., is chairman of the committee in charge.

PURDUE UNIVERSITY

The Purdue Student Section was addressed on January 14 by O. C. Berry, laboratory instructor in the School of Mechanical Engineering. Mr. Berry has spent several years in study and experiment with gas producers as applied to power uses, and took for his subject the General Development and Construction of Power Gas Producers.

LELAND STANFORD JUNIOR UNIVERSITY

The Stanford Mechanical Engineering Society is pursuing the plan of holding joint meetings with the student branch of the American Institute of Electrical Engineers, the Civil Engineering Society, and the Geology and Mining Society. On November 21, George M. Brill, Mem.Am.Soc.M.E., presented a paper on the Engineering of Manufacturing Plants, and on December 4, A. H. Babcock, chief electrical engineer of the Southern Pacific Company, spoke on the Electrification of the Tehachapi.

SYRACUSE UNIVERSITY

C. W. Chandler spoke at the meeting of the Syracuse University student branch on December 22, taking as his topic Locomotive Valve Gears. He described briefly the Stephenson link, radial gear, Baker motion, Marshall gear, and the Walsheart gear, explaining the last at some length.

UNIVERSITY OF ILLINOIS

At the meeting of the student branch of the University of Illinois on December 12, Professor Harding gave a talk on Linoleum Plants, Their Operation and Design. He spoke of the proper selection of the location of the plant and the actual operation of it. Numerous views of the machines used, some of which he had designed, were shown.

UNIVERSITY OF KANSAS

The University of Kansas Student Section held its fifth annual meeting on December 11, which is the date of the formation of the section. At the morning session, Dean Walker gave the greetings of the University, and three papers were presented: Compressed Air Equipment, by B. B. Brewster of the Sullivan Machine Company, St. Louis, Mo.; Survey of Alloy Steels, by Professor Whitaker of the department of metallurgy; and Producer Operating and Testing, by Prof. A. A. Potter, Mem.Am.Soc.M.E., of Kansas State Agricultural College. In the afternoon, papers were given on the Engineer of Today, by Louis Bendit of the Hope Engineering Company, St. Louis; Senior Inspection Trip, by W. J. Malcomson, senior student; Lost Motion, E. B. Black, of Worley & Black, Kansas City, Mo.; Oil Engines, F. L. Weakley of the De La Vergne Machine Company, Kansas City, Mo.; and Efficiency of Power Transmission through Universal Joints, by Earl Carson, senior student. A dinner was given in the evening at which Prof. F. H. Sibley, Mem.Am.Soc.M.E., acted as toastmaster, and brief remarks were made by Professor Walker, L. C. Angevine, Louis Bendit, Clyde Marris, A. H. Sluss and F. L. Weakley.

On January 8 several papers and reports were read, one on a big irrigation project now under way in the beet-sugar fields at Garden City, Kans., by S. Fairchild; one upon a new engine designed for the Wright aeroplane, by F. Hartman; and others upon the design of ice plants, by Malcolm McCune; and on Navigating Barges with Producer Gas Engines, by O. T. Potter.

UNIVERSITY OF MISSOURI

Dr. Charles Elwood gave a talk before the Missouri University student branch on December 15 on Sociology as Applied to Engineering, especially in the field of efficiency engineering and scientific management.

UNIVERSITY OF WISCONSIN

At the regular meeting of the student branch of the University of Wisconsin on January 8 the following officers were elected: M. A. Cook, chairman, J. A. Hinckley, vice-chairman, R. E. Maurer, secretary, R. S. Dewey, treasurer.

UNIVERSITY OF NEBRASKA

Prof. C. L. Dean gave an address before the University of Nebraska student section on January 14, on the Westinghouse Air Brake, in which he traced its development.

On December 17 E. Bignell, superintendent of the Lincoln division, C. B. & Q. R. R., and the inventor of a new pile, spoke before the University of Nebraska student section on the Hydraulic Sinking of Concrete Piles. He related his experiences with the Platte and Missouri rivers, which almost every year washed out a portion of their bridges, and the use of the concrete piles to prevent this. W. O. Forman, efficiency inspector at the Burlington shops, also gave a short explanation of how the piles are made, and C. H. Gerber, state engineer, spoke upon the old and new style of bridges for the shallow Nebraska rivers. Moving pictures of the handling and sinking of these piles were then shown. The meeting was the largest so far held at the University.

WASHINGTON UNIVERSITY

At the meeting of Washington University Student Branch on October 16 the following officers were elected: A. O. Schleiffarth, chairman, Oliver Mann, vice-chairman, W. Seigrist, treasurer, James A. Watkins, Jr., secretary.

On October 30 Walter Seigrist, senior student, read a paper on the Efficiency of Emery Wheels, based upon tests and experiments which he had made. A general discussion followed.

At the meeting of December 2, A. O. Schleiffarth, senior student, read a paper on Boiler Rules and Regulations, in which he compared in detail the requirements of the different states, cities and the United States steamboat service. Special attention was paid to the necessity of a universal boiler law.

The meeting of January 13 was a joint meeting with the student branch of the American Institute of Electrical Engineers. Hans Weichsel, chief engineer of the Wagner Electric Company of St. Louis, presented a paper on Electric Starters for Automobiles, which he illustrated with lantern slides showing various views of the starter and its construction.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The published list of "men available" is made up from members of the Society. Further information will be sent upon application.

POSITIONS AVAILABLE

1223 Member holding patents on dispensing device and carbonating machine desires to come in contact with manufacturing house, who will place these patents on the market; inventions are original and highly thought of by engineers. Apply through the Society.

100 General manager and sales agent wanted for rivet and bolt business with increasing possibilities in the Middle West. Address P. O. Box 1974, Boston, Mass.

102 Two young technical graduates wanted in the maintenance department of New York concern.

105 High grade engineer, sales manager of mechanical experience and ability, technical education and able to direct advertising department and look after domestic and foreign sales of large shop with new equipment and employing 1500 men. Excellent opportunity and future for the right man.

106 Superintendent of plant and equipment in well established company having been in business 30 years manufacturing large quantities of small interchangeable parts, stampings, castings and screw machine parts; man with at least five years executive experience. Apply through the Society.

107 Concern marketing automatic machinery of interest to any trade shipping or packing granular products such as coffee, grain, soap powders, etc., desires to obtain agents to work on commission in the large cities of the United States. Applicants should state definitely what experience they have had with automatic packing machines and firms with which they have been connected. Apply through the Society.

110 Assistant time study man and rate demonstrator, who can operate machine tools and experienced in figuring time standards for manufacturing operations both by observation and experiment. Position pays $25 per week or if applicant has unusual experience in line of work and special rapidity and efficiency will pay more. Location Buffalo.

111 Only men of exceptional ability in design of new metal-working and electrical machinery will be considered; must be able to improve machines and tools now in use, to handle men, gain and hold their confidence and secure their best efforts. Preferably, but not necessarily, a college graduate, with knowledge of construction of motor-driven vehicles and their component parts. Employing company one of the largest in its field. Location middle west. Address C. B. R., 730 Citizens Building, Cleveland, Ohio.

MEN AVAILABLE

40 Position desired as plant manager, or supervisor of economical and efficient operation. Formerly associated in professional efficiency work with noted engineer. Later plant manager, director of economical operation all plants of corporation; left voluntarily to engage independently as efficiency engineer. Desires permanent relationship with large manufacturing organization. Opening salary, $4000 per annum.

41 Member, 36 years of age, graduate mechanical engineer, 15 years' broad and general experience in designing, estimating and constructing various types of mill buildings, factories, railway shops and power stations; thoroughly familiar with all kinds of building construction. At present employed as superintendent on a contract job.

42 Sales engineer, experienced in handling high-grade specialties in power transmission and machinery lines; known to machinery and supply trade of United States and Canada for past eight years.

43 Member, long experience with development and testing of a well-known make of gas engines, passing on the engineering points in hundreds of gas engine contracts and in charge of many difficult trouble cases. Applicant desires a new position with broader outlook. Would undertake steam or gas engine power plant design and operation.

44 General utility executive, technically educated as a mechanical engineer, who, under the titles of assistant vice-president and secretary, has served as a general utility man for well-known manufacturers of machinery; duties including sales, advertising, development of new ideas, pushing out work and general office management; seeks a responsible position where a wide engineering knowledge will be of value.

45 Member, technical graduate, mechanical and electrical engineer who has had broad experience in machinery design, development and manufacture, as designer, chief engineer, and works manager, seeks executive position with manufacturer of electrical or mechanical apparatus, as mining machinery. Reply through the Secretary.

46 Member, graduate mechanical engineer, patent expert, experienced in the design and manufacture of electrical machinery and apparatus and mining machinery; the development of methods and processes of manufacture; the handling materials and general industrial engineering, wishes to become associated with engineering firm having supplemental talent and experience. Reply through the Secretary.

47 Mechanical engineering graduate, three years shop, drafting and office experience. Desires position with future. Willing to start low; preferably commercial or executive work. Age 25; single; location immaterial. Good references.

48 Junior, B. S. and M. E., University of Wisconsin; five years experience in design and manufacture of marine and stationary gasolene and oil engines. Age 25. At present employed. A good proposition requiring ability and responsibility is desired.

49 Member, age 40, specialist in mechanical movements and contrivances, gearing and automatic machinery for special work, would like a position with manufacturing concern desiring a man who will make a study of their machinery and methods, suggest more efficient and economical ways of doing things, invent and design new machines or attachments, and in general improve the quality of the product and decrease costs through the introduction of better mechanical equipment. At present employed in similar capacity.

50 Member, age 40, nine years experience in the teaching of mechanism, descriptive geometry, drawing, and engineering mathematics; six years practice in mechanical engineering work; author of texts in descriptive geometry and mechanism, and articles in engineering journals, successful as teacher, lecturer and manager, desires position in university or technical school.

51 Mechanical engineer, holding managerial position, desires connection with manufacturing concern where executive and administrative ability may be coupled with technical training. Experience covers seven years in foreign and domestic sales. Advertising considered where above qualifications offer opportunity.

52 Member, 38 years of age, desires position as superintendent or factory foreman, practical machinist, ten years experience in charge of shops and departments; competent to organize; thoroughly familiar with all modern manufacturing methods and systems. Location immaterial. Best references.

53 Member, with broad experience in mechanical and structural steel engineering; having energy and business ability; invites correspondence with firms desiring representation in Minneapolis or St. Paul.

54 Member, graduate M. E., age 35, employed at salary of $4000, exceptionally successful in handling men, having broad experience in operating, service, maintenance, construction and design, desires position offering opportunity for wider field of activity than the present one.

55 Member, engineer, 34 years old, married, Englishman, having technical training and a fluent knowledge of the Russian and German languages, with experience in all classes of heavy and light tools, and all types of power plant machinery, wishes to represent in Russia a large American concern. Experience in the United States with the largest firms covers a period of 12 years and embraces purchasing, sales, operation and design.

56 Member, 34 years old, technically trained, for the last seven years in a responsible position with a large industrial concern; experience covers research work, operation, design and construction, desires to connect with a progressive industrial or public service company in the capacity of an engineer executive who can investigate and analyze conditions with the idea of developing and improving a property. Complete details and references upon application.

57 Technical graduate, age 40, thoroughly familiar with recent developments in by-product coke ovens; five years business experience as contracting engineer blast and open-hearth furnace and by-product coke oven construction, desires connection with concern contemplating work in this line.

58 Member; desires position as works manager or general superintendent. Long experience in manufacturing shoe machinery, typewriters, firearms, and automobiles. Experienced designer of production tools, systematizing methods, planning, laying out and routing work through shop, and organizing departments for manufacturing interchangeable parts.

59 Factory manager or superintendent. Experienced mechanic with executive ability, interchangeable manufacturer; high-grade work; low factory cost. No experiment, results assured. New England location preferred.

60 Junior member, graduate mechanical engineer, desires position as mechanical superintendent or engineer of construction, with manufacturing firm; six years experience with consulting engineers and industrial corporations, in design, construction and operation.

61 Member desires position as works manager, superintendent, or engineer; has made time studies a specialty. Best references.

62 Student member, graduate mechanical engineer, one year's experience in construction and valuation of railroads and six months in large manufactory, would like position where permanence and advancement may be looked forward to. At present employed.

63 Member, age 36, technical graduate, ten years commercial experience and five years teaching, now lecturing on heat engineering and in charge of mechanical engineering laboratory in post-graduate department of eastern school, wishes to change. Prefers associate professorship in an institution which has a man to handle machine design and applied mechanics, that he may continue his present specialization; but has had charge of department of mechanical engineering, and can carry whole work if desired.

64 Member, experienced as general or business manager, mechanical engineer, salesman and executive, desires position with manufacturing establishment or branch house; salary $3000.

65 Junior member, age 28, technical graduate in mechanical engineering, experienced in power plant development and general mill engineering, wishes to locate with some progressive company as assistant mechanical engineer or similar capacity.

66 Member; graduate mechanical engineer with broad experience in machine shop, drafting room, erecting and operating; has designed a number of successful internal-combustion engines from 40 to 100 h.p., conducted large and important tests, acted as consulting engineer and in a manufacturing business as one of the proprietors. Desires position as shop or sales manager of a manufacturing company.

67 Associate-Member with technical education, supplemented by four years of sound power plant experience, desires to get in touch with a firm handling a power plant line and having an opening as representative or assistant sales manager.

68 Student member who will graduate June 1914 desires position with good future; four years experience previous to entering College; ambitious and energetic; best references; knowledge of several languages.

69 Junior member, age 27, graduate mechanical engineer, five years experience in automobile manufacture and design, for the last two and one-half years in charge of experimental department in one of the leading automobile factories building a high priced car. At present employed.

70 Junior; graduate mechanical engineer; ten years practical experience in mechanical and electrical lines, erecting power house equipment; master mechanic of large factory; past four years with a sugar company as chief engineer in charge of designing, construction, maintenance and operation of numerous pumping plants and irrigation systems, pipe and power lines, superintendent of city light and water systems; accustomed to figuring costs and purchasing material. Executive ability and excellent references. Employed at present. Address: Box 106, Hamilton City, Cal.

71 Junior; age 31; technical graduate in mechanical and electrical engineering desires position of responsibility with future. Ten years experience in design, superintendence of construction, operation of substations pole and tower lines, as well as testing electrical machinery. Also experienced in high voltage construction and operation. Salary, moderate.

72 Member experienced in successful production and sale of mechanical equipment, seeks association with a concern in need of such personal services where the advantages will prove mutual.

73 Junior member with experience as chief engineer, superintendent of steam turbine power house construction and operation is open for engagement; a specialist in all the modern boiler room economies. Age 32, married, eastern location preferred, but will go anywhere.

74 Mechanical engineer, thoroughly experienced in design of precision machine tools, heavy hydraulic hoisting and pumping machinery; can handle men and get results; familiar with modern methods, and operation of alternating and direct current apparatus.

75 Member, university graduate in mechanical engineering. 17 years practical experience since graduation. Age 40. Specialist in design, construction and operation of all types of dredges and auxiliary plant. Seven years in sole charge of important dredging undertakings. Wishes to hear of opening as mechanical engineer or other responsible position, preferably with dredging firm. Highest references.

76 Member, graduate mechanical engineer Worcester Polytechnic Institute, two years law study, several years experience in charge of experimental engineering; six years as Chicago manager for Pratt and Whitney Company; several years experience in manufacturing as superintendent, works manager, and general manager. Is desirous of a permanent connection with a reliable enterprise either as general manager, works manager, or advisory and reorganizing engineer.

77 Member, technical, 36 years of age, 14 years' experience in the design, erection and maintenance of steam power plants and manufacturing plants, desires position as construction engineer or mechanical superintendent with some large manufacturing plant. At present employed as resident engineer.

78 Managing sales engineer, open for contract to build up business with New York as headquarters. Have specialized in power plant equipment, contractors and conveying machinery. Practical shop and field experience; diplomatic and progressive.

79 Junior member, Stevens graduate, M. E., aged 28, at present employed, desires position as mechanical engineer. Has had some years' experience in shop work, drafting room

designs and engineering practice with firm designing and building refuse incinerators and steam power plant equipment.

80 Member, at present employed, 18 years' varied experience in design and construction of machinery and buildings, remodeling, maintenance and operation of large industrial plants and equipment, systematizing of shops and processes along the lines of scientific management and efficiency, testing and general plant engineering; accustomed to handling men, drawing up contracts, purchasing equipment and material, appraising properties; desires to become identified with manufacturing or industrial plant of prominence in administrative or executive position of responsibility in which his experience may be of value. Best of references.

81 Mechanical engineer, technical graduate, age 30, desires responsible position. Thorough knowledge of all types of pumps and pumping machinery, gasolene and oil engines, steam engines, and sugar house machinery. Drawing room, erection room and engineering department experience in large pump manufacturing company. Sugar plantation work in Mexico and sales engineer in Brazil. Natural ability in handling men and getting results. Best of references.

82 Associate-Member, graduate M. E., 29 years old, would like position with reliable concern. Experienced in design and construction of power and industrial plants including surveying and some operation. Would not object to some drafting work; sales proposition would be considered. Salary according to position and location. Location no object.

83 Member, technical graduate, desires position as works manager or general superintendent, experienced in foundry and machine shops, a good executive and manager of men.

84 Member, M. I. T. graduate, experienced as office, advertising and sales manager wants position with growing concern. A congenial, permanent and eventually profitable affiliation more important than initial salary.

85 Member, desires position either as superintendent, designer or sales engineer, New York City or vicinity; has a clear record for past work.

86 Graduate mechanical engineer, twelve years' practical experience; has made specialty of experimental research work in compressed air machinery; also experienced in structural work, boilers, hydraulics and magazine editorship on machine shop practice. Would like position as college instructor in mechanical engineering; especially trained and fitted for laboratory work.

ACCESSIONS TO THE LIBRARY

WITH COMMENTS BY THE LIBRARIAN

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary Am. Soc. M. E.

AERONAUTICS IN THE ARMY. Hearings before the Committee on Military Affairs. *Washington, 1913.* Gift of U. S. army.

AMERICAN ASSOCIATION OF COMMERCE AND TRADE, BERLIN. Report of 11th annual general meeting, 1913. Gift of association.

AMERICAN ASSOCIATION OF PUBLIC ACCOUNTANTS. Yearbook 1912-1913. *New York, Ronald Press Co., 1913.*

AMERICAN CERAMIC SOCIETY. Trans. vol. 15. *Columbus, 1913.* Gift of society.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Index to Trans. vols. 1-34; also the Journal, January-November, 1913. (Manuscript.)

AMERICAN WOODS, R. B. Hough, pt. 13. *Lowville, 1913.*

ARCADE UNDERGROUND RAILWAY. Report of E. L. Viele.

BAUMATERIALIENKUNDE. vols. 1-6, 8-12. *Stuttgart, 1896-1901, 1903-1907.*

CENTRALIZED CONTROL SYSTEM AND POWER STATION SWITCHBOARDS FOR THE PANAMA CANAL, E. M. Hewlett. From Switchboard News, January, 1914. Schenectady, 1914. Gift of E. M. Hewlett.

CHEMISCHE TECHNOLOGIE DER GESPINSTFASERN, Karl Stirm. *Berlin, 1913.*

CONNECTICUT. BUREAU OF LABOR STATISTICS. Labor laws and directory of labor organizations of Connecticut, 1913. *Hartford, 1913.*

———Bul. no. 1. Workmen's Compensation. *1913.* Gift of bureau.

EXPOSE OF THE FACTS CONCERNING THE PROPOSED ELEVATED PATENT RAILWAY ENTERPRISE IN THE CITY OF NEW YORK, 1866. *New York, 1866.*

FLUGZEUG MODELLBAU, P. L. Bigenwald. From Bibliothek für Luftschiffahrt und Flugtechnik, vol. 12. *Berlin, 1914.*

FOWLER'S MECHANICAL ENGINEER'S POCKET BOOK, 1914. Edited by W. H. Fowler. ed. 16. *Manchester, 1914.*

FOWLER'S MECHANICS' and MACHINISTS' POCKET BOOK AND DIARY, 1914. Edited by W. H. Fowler, ed. 6. *Manchester, 1914.*

These very cheap little books, containing about 550 and 450 pages respectively, and selling for 40 cents and 12 cents, are full of practical data and tables. They must have wide use to be sold so cheaply.

DIE GEISTIGEN MITTEL DES TECHNISCHEN FORTSCHRITTES IN DEN VEREINIGTEN STAATEN VON AMERICA, Conrad Matschoss. *Berlin, 1913.*

GYROSCOPE, F. J. B. Cordeiro. *New York, 1913.*

LES IDEES MODERNES SUR LA CONSTITUTION DE LA MATIERE. CONFÉRENCES FAITES en 1912. From Société Française de Physique. *Paris, 1913.*

INDIANA ENGINEERING SOCIETY. 33d annual report, 1913. *Indianapolis, 1913. Gift of society.*

INDUSTRIAL CHEMISTRY FOR ENGINEERING STUDENTS, H. K. Benson. *New York, The Macmillan Co., 1913.*

This college text-book has one unusual feature which commends it to a librarian. Each chapter has appended an extensive bibliography. This leads one to suspect that the author, who is a professor of industrial chemistry in the University of Washington, requires his students to examine the literature of each subject, a plan too seldom followed in technical schools.

INTERNATIONAL CONGRESS ON HYGIENE AND DEMOGRAPHY (15). Trans. vols. 2 and 3, pts. 1-2; vol. 4. *Washington, 1913.*

KONTROLLE DER MALZEREI UND BRAUEREI ARBEITSMASCHINEN, G. Jakob. From Oldenbourgs Technische Handbibliothek, vol. 19. *München, 1913.*

DIE KUGELLAGER UND IHRE VERWENDUNG IM MASCHINENBAU, W. Ahrens. From Einzelkonstruktionen aus dem Maschinenbau, pt. 4. *Berlin, 1913.*

LABORATORY ENGINEERING, H. G. Taylor. *London, 1913.*

LAYING OUT FOR BOILER MAKERS AND SHEET METAL WORKERS. ed. 2. *New York, 1913.*

LEÇONS SUR LA THÉORIE DES NOMBRES, A. Chatelet. *Paris, 1913.*

LOUISIANA ENGINEERING SOCIETY. Officers and Members, 1913. Gift of the society.

MANUFACTURE OF REINFORCED CONCRETE POLES, PILES AND PIPE WITHOUT THE USE OF FORMS, R. M. Jones. *Denver.* Gift of author.

MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION. Proc. 44th annual convention, 1913. *1913.* Gift of association.

MODERN GAS TRACTOR, ITS CONSTRUCTION, UTILITY, OPERATION AND REPAIR, V. W. Pagé. *New York, 1914.*

NATIONAL ASSOCIATION OF CAR SERVICE MANAGERS (now known as American Association of Demurrage Officers) Proc. 1891-1894, 1896-1899, 1901, 1902, 1905-1906, 1908-1910. Gift of association.

NATIONAL CONSERVATION CONGRESS (5th). Forestry Committee. Closer Utilization of Timber. Washington, 1913. Lumbering. *Washington, 1913.* Gift of Calvin W. Rice.

OIL PRODUCTION METHODS, P. M. Paine and B. K. Stroud. With a chapter on Accounting Systems by W. F. and W. B. Sampson. *San Francisco, Western Engineering Publishing Co., 1913.*

A book for the practical man. After 50 pages on the distribution, property and uses of petroleum, the remainder of the book is devoted to the practice of oil-well drilling, going into extreme detail. The last chapter is devoted to accounting systems. The book describes California practice.

PRACTICAL MARINE ENGINEERING FOR MARINE ENGINEERS AND STUDENTS. ed. 3. *New York, 1914.*

PRINCIPLES OF THERMODYNAMICS. G. A. Goodenough. ed. 2. *New York, 1912.*

REARRANGEMENT AND DEVELOPMENT OF THE STEAM RAILROAD TERMINALS OF THE CITY OF CHICAGO. Report on. B. J. Arnold. *Chicago, 1913.* Gift of author.

SEEHAFENBAU. F. W. Otto Schulze. vols. 1 and 2. *Berlin, 1911, 1913.*

DAS STÄDTISCHE GASROHRNETZ. Paul Brinkhaus. From Oldenbourgs Technische Handbibliothek, vol. 18. *München, 1913.*

TECHNISCHE ELASTIZITÄTSLEHRE. Hans Lorenz. From Lehrbuch der Technischen Physik, vol. 4. *München, 1913.*

U. S. INTERSTATE COMMERCE COMMISSION. 2d Annual Report, November 1, 1913, of the Chief Inspector of Locomotive Boilers. *Washington, 1913.* Gift of commission.

WESTERN RAILWAY CLUB. Proc. 1912-13. *Chicago, 1913.* Gift of club.

ZAHNRÄDER. Räder mit schragen Zähnen. A. Schiebel. pt. 2. From Einzelkonstruktionen aus dem Maschinenbau, pt. 5. *Berlin, 1913.* Gift of Central des Associations Internationales.

LE MUSÉE INTERNATIONAL. Notice-Catalogue. Publication no. 27a. 1914.

UNION OF INTERNATIONAL ASSOCIATIONS AND THE INTERNATIONAL CENTER. Publication no. 60. 1913.

LA VIE INTERNATIONALE. vol. 4, nos. 2-4. *Bruxelles, 1913.*

EXCHANGES

AMERICAN RAILWAY ENGINEERING ASSOCIATION. Proc. 14th annual convention, vol. 14. 1913.

INSTITUTION OF GAS ENGINEERS. Trans. 1913. *London, 1913.*

INSTITUTION OF NAVAL ARCHITECTS. Trans. vol. 55, pt. 2. *London, 1913.*

VICTORIAN INSTITUTE OF ENGINEERS. Proc. vol. 12. *Melbourne, 1913.*

TRADE CATALOGUES

BARTON MFG. CO., *New York, N. Y.* Cat. no. 29, rubber stamps, numbering machines, ink pads, etc., 152 pp.

BEAN SPRAY PUMP CO., *Cleveland, O.* Cat. no. 29, spray pumps and accessories, 47 pp.

BLISS, E. W. CO., *Brooklyn, N. Y.* Approximate diameter of blanks for shells from 1/4 in. diameter by 3/4 in. high to 12 in. diameter 12 in. high.

BROWN HOISTING MACHINERY CO., *Cleveland, O.* Brown hoist hand-traveling cranes.

GARDNER MACHINE CO., *Beloit, Wis.* Gardner grinder, November-December 1913.

GOULDS MFG. CO., *Seneca Falls, N. Y.* Goulds fig. 423, adjustable stroke pump.

INGERSOLL-RAND CO., *New York, N. Y.* Story of Imperial air compressor.

MESTA MACHINE CO., *Pittsburgh, Pa.* Bul. K, gears and rolling mill pinions.

UNDER-FEED STOKER CO. OF AMERICA, *Chicago, Ill.* Publicity magazine, December 1913.

UNION ELECTRIC LIGHT & POWER CO., *St. Louis, Mo.* Union electric bulletin, August 1913.

UNITED ENGINEERING SOCIETY

CARNOTITE, THE PRINCIPAL SOURCE OF RADIUM. T. F. V. Curran. *New York, 1913.* Gift of Curran & Hudson.

HISTORIC PRIORITIES IN LYNN. And address given at the dedication of the society house, Lynn Historical Society, October 9, 1913. C. J. H. Woodbury. *Lynn, 1913.* Gift of C. J. H. Woodbury.

MERCANTILE MARINE ATLAS. Edited by George Philip. ed. 4. *New York, 1913.*

RELATION OF WEST VIRGINIA COALS TO THE PANAMA CANAL. Address of Ex-Governor W. A. MacCorkle before the West Virginia Coal Mining Institute, December 8, 1913. Gift of West Virginia Coal Mining Institute.

STREET DIRECTORY OF THE PRINCIPAL CITIES OF THE UNITED STATES, EMBRACING LETTER-CARRIER OFFICES ESTABLISHED TO April 30, 1908. ed. 5. *Washington, 1908.*

TEST OF A 40-FT. REINFORCED CONCRETE HIGHWAY BRIDGE. D. A. Abrams. Gift of author.

WORLD'S FAIR BULLETIN. Louisiana Purchase Exposition, 1904. Gift of St. Louis Public Library.

GIFT OF INTERNATIONAL SAFETY EXHIBITION, 1913

EDUCATIONAL AND OTHER EMPLOYEE RELATIONS INCLUDING OUTLINE OF EDUCATIONAL COURSES, 1913-1914. *New York Edison Company, 1913.*

A NATION'S NEGLECT. M. A. Low.

RESUSCITATION FROM ELECTRIC SHOCK. C. A. Lauffer.

SAFETY. vol. 1, no. 3, August 1913.

STOP, LOOK, LISTEN. F. V. Whiting.

EXPERIMENTS ON THE FLOW OF AIR OR GAS IN PIPES

PARTIAL BIBLIOGRAPHY

Prepared in the Library of the Engineering Societies

PITOT TUBES FOR GAS MEASUREMENT. W. C. Rowse. *American Society of Mechanical Engineers, Journal,* September 1913, pp. 1321-1380. With references in the footnotes.

UNTERSUCHUNG ÜBER DIE LUFTVERTEILUNG EINER VERZWEIGTEN EXHAUSTORANLAGE. D. Eie and H. Ovenberg. *Zeit. des Vereines Deutscher Ingenieure,* December 6, 1913, pp. 1943-1946. Abstract in *American Society of Mechanical Engineers, Journal,* February 1914.

POWER SUPPLY ON THE RAND. A. E. Hadley. *Institution of Electrical Engineers,* vol. 51, no. 220, pp. 2-31; discussion p. 31-58, 1913. Abstract in *American Society of Mechanical Engineers, Journal,* January 1914, p. 018. Monthly tests were made of the compressed air system.

MEASURING THE FLOW OF AIR IN PIPES. G. G. Crewson. *Compressed Air,* vol. 17, pp. 6636-6638, December 1912.

PROBLEMS IN NATURAL GAS ENGINEERING. Thos. R. Weymouth. *American Society of Mechanical Engineers, Trans.,* vol. 34, pp. 185-231; discussion pp. 231-234, 1912. Mention is made of various experiments on the flow of air in pipes.

MEASUREMENT OF AIR IN FAN WORK. Charles H. Treat. *American Society of Mechanical Engineers, Trans.,* vol. 34, pp. 1019-1045; discussion pp. 1046-1054, 1912. The author discusses the use of the pitot tube for fan testing, but the average velocity of flow in a pipe is briefly considered.

SOME RECENT DEVELOPMENTS IN GAS MEASURING APPARATUS. C. C. Thomas. *American Gas Institute,* vol. 7, pp. 340-381, 1912.

THE RESISTANCE TO THE FLOW OF AIR THROUGH PIPES. A. H. Gibson. *Engineering* (London), vol. 94, p. 703, November 22, 1912.

THE PITOT TUBE APPLIED TO THE MEASUREMENT OF AIR. Lee Loeb. *American Society of Naval Engineers,* vol. 24, pp. 1115-1145, 1912. A record of tests undertaken to determine the ratio of average velocity to center velocity at velocities between 1000 and 3000 ft. per minute.

SUR L'ECOULEMENT DE L'AIR DANS LES CONDUITES DE VENTILATEURS. Ch. Reignier. *Technique Moderne,* February 15, 1912, pp. 129-133. Describes methods of determining the mean velocity of flow, with examples from a test.

RESONANZERSCHEINUNGEN IN DER SAUGLEITUNG VON KOMPRESSOREN UND GASMOTOREN. P. Voissel. *Zeit. des Vereines deutscher Ingenieure,* vol. 56, pp. 720-722, 1912. Abstract in *American Society of Mechanical Engineers, Journal,* August 1912, pp. 1248-1250.

FLOW OF GAS IN MAINS. J. W. Batten. *American Gas Institute, Proc.,* vol. 6, pt. 1, pp. 369-396; discussion pp.

396-400, 1911. *American Gas Light Journal,* March 4, 1912, pp. 148-155.

THE MEASUREMENT OF GASES, Carl C. Thomas. *Franklin Institute, Journal,* vol. 172, p. 411-460, 1911.

THE FLOW OF GAS THROUGH SMALL PIPES. *Engineering Record,* vol. 62, pp. 384, 1910. Abstract of account published in the *Journal of Gas Lighting* of experiments made by D. Chandler, under the direction of Charles Carpenter.

FRICTION IN SMALL AIR PIPES, E. G. Harris, Albert Park and H. H. Peterson. *School of Mines and Metallurgy, University of Missouri, Bulletin,* September 1910. From data collected for a thesis. Abstract in *Mining Science,* November 17, 1910.

THE FLOW OF GAS THROUGH AND OUT OF SMALL PIPES, T. Holgate. *Gas World,* vol. 53, pp. 293-297, 1910. Examples showing that in computations, separation of pressure expended in efflux and flow is essential.

AN INVESTIGATION OF THE RESISTANCE TO THE FLOW OF AIR THROUGH A PIPE, WITH THE DEDUCTION AND VERIFICATION OF A RATIONAL FORMULA, A. H. Gibson. *Philosophical Magazine,* vol. 17, ser. 6, pp. 389-402, 1909.

ON FRICTIONAL RESISTANCES TO THE FLOW OF AIR THROUGH A PIPE, John H. Grindley and A. H. Gibson. *Royal Society of London, Proc.,* vol. 80, ser. A, pp. 114-139, 1908.

UNTERSUCHUNGEN ÜBER DEN AUSFLUSS KOMPRIMIERTER LUFT AUS KAPILLAREN UND DIE DABEI AUFTRETENDEN TURBULENZERSCHEINUNGEN, Dr. Ruckes. *Zeit. des Vereines deutscher Ingenieure,* vol. 52, pp. 2065-2068, 1908. Experiments on the flow of compressed air in very small pipes.

UNTERSUCHUNGEN ÜBER DEN STRÖMUNGSEIDERSTAND DER GASE IN FERADEN ZYLINDRISCHEN ROHRLEITUNGEN, Dr. Fritzsche. *Zeit des Vereines deutscher Ingenieure,* vol. 52, pp. 81-91, 1908. Abstract of report in *Mitteilungen über Forschungsarbeiten.* Gives results of experiments to determine the influence of velocity, temperature, pressure and tube diameter. The first table gives a list of previous investigations.

EXPERIMENTS WITH VENTILATING FANS AND PIPES, D. W. Taylor. *Society of Naval Architects and Marine Engineers, Trans.,* vol. 13, pp. 9-13; discussion pp. 43-70, 1905.

EXPERIMENTS WITH THE PITOT TUBE IN MEASURING THE VELOCITIES OF GASES IN PIPES, R. Burnham. *Engineering News,* vol. 54, pp. 660-662, 1905.

TESTS OF THE FLOW OF HIGH PRESSURE GAS. *Journal of Gas Lighting,* vol. 92, pp. 750-751, 1905. Abstract of paper by H. L. Price before the American Gas Light Association.

FLOW OF GAS IN PIPES, J. D. Shattuck. *American Gas Light Journal,* vol. 82, pp. 648-650, 1905. Report of committee at meeting of Ohio Gas Light Association.

FLOW OF AIR IN METAL PIPES, J. H. Kinealy. American *Society of Heating and Ventilating Engineers, Trans.,* vol. 11, pp. 188-96; discussion pp. 196-198, 1905.

VERSUCHE ÜBER DEN WIDERSTAND BEI BEWEGUNG DER LUFT IN ROHRLEITUNGERE, H. Rietschel. *Gesundheits Ingenieure,* July 1905.

FLOW OF AIR IN PIPES AND THE TRANSMISSION OF POWER BY COMPRESSED AIR. *Mines and Minerals,* vol. 25, pp. 616-617, 1905.

MOTION OF GASES IN PIPES, AND THE USE OF GAGES TO DETERMINE THE DELIVERY, Richard Threlfall. *Institution of Mechanical Engineers,* 1904, pt. 1-2, pp. 245-296; discussion pp. 297-312.

PRACTICAL OBSERVATIONS ON THE FLOW OF GASES IN PIPES, L. P. Lowe. *American Gas Light Journal,* vol. 81, pp. 483-486, 1904. Paper read before Pacific Coast Gas Association.

A DISCUSSION OF LEDOUX AND UNWIN'S FORMULAE FOR THE FLOW OF AIR IN PIPES, WITH REFERENCE TO HEATING AND VENTILATING, H. Diedericks. *Sibley Journal of Engineering,* vol. 16, pp. 312-320, 1902.

EXPERIMENTS MADE BY THE PRUSSIAN MINING COMMISSION IN 1884 ON THE MEASUREMENT OF AIR IN A PIPE BY DIFFERENT METHODS, FROM A LARGE AIR-HOLDER AT THE BRESLAU GAS WORKS. *Institution of Civil Engineers,* vol. 122, pp. 281-282, 1894-1895.

MEASUREMENT OF THE VELOCITY OF AIR IN PIPES, Bryan Donkin. *Institution of Civil Engineers,* vol. 111, pp. 345-351, 1892-1893.

THE COEFFICIENT OF FRICTION OF AIR FLOWING IN LONG PIPES, W. C. Unwin. *Institution of Civil Engineers,* vol. 63, pp. 297-300, 1880-1881.

BOOKS

CARPENTER, ROLLA C. Heating and Ventilating Buildings. Ed. 5. *New York, Wiley, 9111,* pp. 48-51.

CHURCH, IRVING P. Mechanics of Engineering. Revised ed. *New York, Wiley, 1908.* Chap. 8. Kinetics of gaseous fluids.

HARRIS, ELMO G. Compressed Air, Theory and Computations. *New York, McGraw-Hill Book Co., 1910.* Appendix B, pp. 118-123, contains data on friction in air pipes, based on various experiments. The date of each experiment is given, with the names of persons making the observations.

HISCOX, GARDNER D. Compressed Air, its Production, Uses and Applications. *New York, Henley Publishing Co., 1901,* pp. 216-222.

HOLE, WALTER. The Distribution of Gas. Ed. 2. *London, John Allan,* preface date, *1909.*

KENT, WILLIAM. Mechanical Engineer's Pocket book. Ed. 8. *New York, Wiley, 1910,* pp. 591-594.

WEISBACH, JULIUS. Mechanics of Engineering; Theoretical Mechanics, with an Introduction to the Calculus. Translated from the fourth German edition by Eckley B. Coxe. Eighth American edition. *New York, Van Nostrand, 1889,* pp. 949-952.

PERSONAL NOTES

John E. Sweet, Honorary Member and Past-President of the Society, was given the degree of Doctor of Engineering at the midwinter meeting of the board of trustees of Syracuse University. Following this, at a meeting of the Technology Club of Syracuse, resolutions were adopted expressing the appreciative feeling of the local engineers, which fittingly represents also the views of the larger circle of engineers throughout this country and abroad, who are numbered among his friends:

Whereas, a member of this Club, eminently distinguished and of international fame in his profession, on the 10th day of January, 1914, received from Syracuse University the honorary degree of Doctor of Engineering, and

Whereas, said member is held in high esteem and affectionate regard, making this mark of distinction a matter of warm approval and personal gratification to every member, now therefore,

Be it Resolved, that the Technology Club of Syracuse, convened in regular session this 9th day of February, 1914, offer heartiest congratulations to its charter member, honorary member, and first president, John Edson Sweet, upon this academic acknowledgment and approval of his worth as an engineer, an educator and a man, and permanently record its pride in the possession of his inspiring personality, valued helpfulness, and, best of all, his constant friendship.

Prof. F. R. Hutton, Honorary Secretary, left on February 14 for Southern California to attend the Santa Monica races, where he will represent the Automobile Club of America. On his return journey he will endeavor to visit some of the Student Branches of the Society, as Chairman of the Committee on Student Branches.

Lewis D. Freeman has resigned as chief draftsman of the Kansas City Southern Railway Company, Pittsburg, Kan., to accept the position of mechanical inspector of the Seaboard Air Line Railway, with headquarters at Portsmouth, Va.

Robert A. Wilson has accepted a position as master mechanic of the Producers Oil Company, Houston, Tex. He was formerly connected with the Ohio Works of the Carnegie Steel Company, Youngstown, Ohio.

Perry J. Freeman has left the service of the Gullett Cotton Gin Company, Amite, La., and is now connected with the Kansas State Agricultural College, Kanhattan, Kan., as instructor in charge of applied mechanics and hydraulics laboratory.

Prof. A. R. Acheson, head of the department of mechanical engineering of Syracuse University, has been appointed consulting engineer for the Bureau of Gas and Electricity of Syracuse. Professor Acheson will not sever his connections with the University, but will devote only part of his time to the work of the bureau.

Wilbur N. Sar Vant has severed his connection as assistant engineer with the American Process Company, New York, to accept the position of mechanical engineer of the Hunsicker Engineering Company, Lebanon, Pa.

STUDENT BRANCHES

CARNEGIE INSTITUTE OF TECHNOLOGY

A meeting of the Student Branch of the Carnegie Institute of Technology was held on January 14. The paper of the evening, Hydraulic Forging Presses, was presented by Mr. Noble of the class of 1909, who described the construction, operation and relative merits of the more representative types of hydraulic forging presses being built in this country and Europe, and pointed out the advantages to be derived by the use of hydraulic presses instead of steam hammers. The paper was illustrated by lantern slides.

CASE SCHOOL OF APPLIED SCIENCE

Willard Beahan, first assistant engineer of the Lake Shore Railroad, presented a paper on the Engineering of Men at the meeting of the Case School of Applied Science on February 5.

KANSAS STATE AGRICULTURAL COLLEGE

At the meeting of the Council on February 13, permission was granted for the formation of a Student Branch at the Kansas State Agricultural College.

LEHIGH UNIVERSITY

On February 10 the Lehigh Mechanical Engineering Society held a meeting at which papers were presented on the Diesel Motor, by George F. Nordenholt (Student 1914), giving the history of the motor and describing some installations he had seen while abroad; and on Heating and Ventilating, by R. L. Spencer of the mechanical engineering department, developing several formulae on the subject and showing their use.

POLYTECHNIC INSTITUTE OF BROOKLYN

The monthly meeting of the Polytechnic Institute of Brooklyn Student Branch was held on February 7, the subject for discussion being the features of the inspection trip recently made to Schenectady, Buffalo, Niagara, Scranton and Wilkes-Barre. Impressions of the power plant of the Rensselaer night boat were given by Frederick Holmgreen, of the American Locomotive Works by Merritt Van Valkenburgh, of the hydroelectric plant of Niagara by George A. Wieber, of the Carborundum Works and the Shredded Wheat Biscuit Company by David Bonavety, of the General Electric Works by Paul Newman, and of the coal mines of Scranton by George A. Mebor.

UNIVERSITY OF CALIFORNIA

At the meeting of the Student Branch of the University of California on January 27, an illustrated lecture was given by Bert Barr on the Machinery of the Panama Canal.

UNIVERSITY OF CINCINNATI

The University of Cincinnati Student Branch was addressed at its meeting of January 20 by Parker H. Kemble on the Construction of the Brooklyn Subway. The important difficulties incident to the construction were discussed and the methods of their attack briefly outlined. Slides showing views of the work during the different stages of development and of novel "hitch-ups" were used to supplement the lecture.

UNIVERSITY OF KANSAS

On January 22 the Student Branch of the University of Kansas, Prof. A. J. Boniton of the economics department gave an address on Recent Industrial Legislation, in which he discussed at some length the new system of banking, explaining the need, its organization, method of operation and its probable effect on business. While somewhat out of the engineering field, the address created much discussion and aroused the interest of the members.

UNIVERSITY OF NEBRASKA

The Student Branch of the University of Nebraska held a meeting on February 3 at which Prof. P. K. Slaymaker gave a talk on the Manufacture of Iron in which he briefly

described the character and value of the ores and where they are mined. He outlined some of the many difficulties experienced in designing a good working furnace and showed the general layout of a blast furnace plant with the ore handling apparatus.

YALE UNIVERSITY

At the meeting of the Yale Student Branch on December 16, Frank Gilbreth gave a talk on how to obtain least waste and minimum movement of operator for each operation, which was illustrated by lantern slides.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The published list of "men available" is made up from members of the Society. Further information will be sent upon application.

POSITIONS AVAILABLE

1210. Sales engineers; applications invited from young men 30 to 35 years old who have had thorough machine-shop training, preferably in tool making, design, and with some experience in selling; technical education preferred.

112 Senior draftsman, three or fours years' experience in the design and supervision of construction of isolated power plants, and all of the engineering work, excepting structural, embracing heating, ventilation, electrical and plumbing work, kitchen and laundry layouts, refrigeration systems, pipe lines and distribution systems between buildings, sewage and sewage disposal systems, fire protection and work of similar nature incidental to institutional and building work. Location, Baltimore.

113 Lubrication engineer on sale of high-grade lubricating oils, must have considerable experience in connection with the operation of steam engines and mill machinery; one who has made a specialty of studying lubrication; a diplomat and a good mixer. Would be expected to visit large plants, inspect engines and machinery in connection with the recommendation of proper lubricants to be used, which necessitates a full knowledge of this phase of the business. Salary depends upon ability of the man.

201 Librarian for engineering library devoted to mechanical, electrical and mining engineering. Preference would be for one who has had some engineering training, preferably collegiate, who is able to translate and abstract articles published in technical German and French, especially in the former, and who can keep the library up to date, help students in finding references, assist members of the faculty in compilations, etc. Salary for present not over $1000 a year. Location, New York State.

202 Technical graduate for concern manufacturing small accurate electrical apparatus and motors. Work will consist of investigations on accuracy and limits of accuracy in matters of production, working out specific basis for determining production in regard to quantity and quality. Some chemical knowledge required. Applicants are requested to give details on technical education, business experience, references, age and salary. Name confidential; apply through the Society.

203 Busy executive of large western machine works wants an assistant; must be ambitious, energetic young man, technically trained, experienced in handling office details, correspondence, salesmen and with some personal selling ability. Prefer one with knowledge of wood working machinery. This is an exceptional opportunity for one seeking a wider horizon than possible through general shop work.

205 Draftsman or designer familiar with proportions and design of Curtis turbine blading; must be capable of laying out blading to secure the best steam efficiency, including plotting and calculations. Location, Connecticut. Applicant must have the actual experience for this work, otherwise useless to apply. Name confidential; apply through the Society.

206 Man to settle disputes that may arise along railway construction work and operation. Will necessitate a great deal of traveling. Preference given man with knowledge of car building, able to act or qualify as chief car inspector. Apply through the Society.

207 An engineer, thoroughly experienced in the design and operation of oil engines. Should be familiar with foreign development and practice. State age, experience, compensation. Name confidential; apply through the Society.

208 Vice president and general manager of sales; an engineer of highest mechanical experience and ability; able to direct advertising department and look after domestic and foreign sales of large shop employing 1500 men. Name confidential; apply through Society.

209 Wanted: Tool designer with several years' experience on jigs and fixtures, for the production of small interchangeable parts for electrical apparatus, also typewriter and adding machines. Only those with practical shop experience need apply. Applicants please state age, references and salary.

210 Mechanical engineer to take charge of power plant connected with brick manufacturing concern having four factories near Trenton, N. J.

211 Wanted: Assistant to superintendent of machine shop in Milwaukee. Man with technical education and one capable of taking charge of perfecting new apparatus. State experience and salary desired.

210 Wanted for the next college year, an instructor in machine shop practice in a large western university. Salary $1600. Applicant must be a skilled machinist, capable of designing and making special tools used in manufacturing machinery. Familiarity with scientific methods of shop management is desirable.

212 Mechanical engineer to take charge of power plant connected with brick manufacturing concern having four factories near Trenton, N. J.

213 A young man with technical training, who has had two or three years' experience in the construction or operation of gas plant or gas plant machinery, wanted by a manufacturing firm in Middle West for installation work in this country on a new high-grade apparatus used in the gas industry. Good opportunity for the right man. Name confidential; apply through the Society.

214 New Jersey concern are in constant need of men about four years out of college, willing to start at $25 a week as apprentices. Character the first requisite, after that general ability for executive and manufacturing work. Apply through the Society.

215 Assistant to president; bright, energetic young engineer, not over 30, with shop and drawing room experience and a basis of good common sense and personality. Excellent training for young man who has the personality and ability to advance and learn the lessons from daily experiences, who can adapt himself to the special conditions and become conversant with line of manufacture of pneumatic machinery, saws and saw-mill machinery, manganese steel castings. Location, St. Louis, Mo.

216 Assistant to works manager of concern manufacturing pneumatic machinery, saws and saw-mill machinery, manganese steel castings. Requirements and conditions same as stated in No. 215. Location, St. Louis, Mo.

217 Competent and trained engineer who is specialist in safety appliances wanted by state industrial commission of the Middle West.

218 Master mechanic for Brooklyn mill; man who understands steam engineering and general repair work on machines, with shop experience; will probably pay $2000 to $2500, according to ability.

219 Mechanical engineer to take the position of chief engineer in a rubber company's factory. Experience in construction work, executive ability. Applicant should be not less than 30 and not more than 45 years of age. Only men having practical experience need apply. Works include machine, electrical and carpenter shops, drafting room and office force. State salary expected, experience and age. Location, New York.

220 Technically educated man for catalogue work on can-making machinery. Applicant need not be educated in can-making nor can-making machinery, but must have the qualifications for describing clearly the essential features of machines and details of operation.

221 The sales department of a large manufacturing company in New England is looking for a good, live, young man, who is well educated, has a knowledge of mechanics, and is a good correspondent. A graduate mechanical engineer with some commercial experience would be preferred. A full reply giving age, whether married or single, experience, present occupation, references and salary expected will receive attention and will be treated confidentially. Name confidential; apply through the Society.

MEN AVAILABLE

100 Engineer, young, married, technical graduate with thoroughly practical experience in management of mechanical workshops, at present employed as manager of a plant producing a well-known line of motor trucks, would like to make a similar connection with another company in any line of manufacture. Location immaterial.

101 Junior member, technical graduate, six years' experience power plant efficiency, operation, design and construction work. Wants position as mechanical or efficiency engineer. Salary $175 to $200 per month.

102 Mechanical engineer, thoroughly experienced in design of precision machine tools, heavy hydraulic hoisting and pumping machinery; can handle men and get results; familiar with modern methods, and operation of alternating and direct-current apparatus.

103 Member, graduate mechanical engineer, desires permanent connection as designing or production engineer with concern manufacturing gas, gasolene engines or automobiles. Eight years' experience in these lines. Age 30; married. Can give best of references.

104 Member, graduate of Massachusetts Institute of Technology; 15 years' experience in textile manufacturing, mill engineering and shop management; broad executive experience as works manager and superintendent of large machine shop. Experienced in most advanced practice in shop organization. Position desired as factory manager or superintendent of plant engaged in staple manufacturing.

105 Member, now employed, desires change, capable mechanical engineer or chief draftsman, to take complete charge of drafting room designing boilers, engines, locomotives, steel cars, special mechinery, power plants and structural work. Location immaterial.

106 Graduate electrical engineer, nine years' experience with present employer, a well-known pioneer motor truck manufacturer, holding positions as designing and production engineer, factory manager, and branch manager in charge of sales through western New York and Pennsylvania. Able executive.

107 Executive mechanical engineer of wide experience, capable of filling position of chief engineer on large projects, is open for engagement. Familiar with heavy construction work and the economical methods of handling materials. Can organize a large construction force that will produce results. Will undertake any engineering work on salary or commission. Member, married, age 40.

108 Heating, ventilating and power plant, member, 28 years' experience, available for superintendence and design with architects or consulting engineers.

109 Mechanical engineer or superintendent for large corporation; experience along broad mechanical and steam power lines; executive, with ability to handle large number of men, or will consider proposition to act as consulting engineer.

110 Member, desires position as works manager, superintendent, or chief inspector. Good executive, has handled men for the last 12 years. Experience covers a period of 22 years. Both large and small machinery, including printing presses, conveying machinery, typewriters, and ball, roller, and thrust bearings. Experience in organizing and directing inspection departments. At present employed. Permanent position desired.

111 High-grade electrical and mechanical engineer, 38 years of age, first-class executive, who has headed large organizations, both in constructional and manufacturing work. Has had charge of important government work as well as corporation work. Experienced in sales organization, decidedly aggressive and a good developer. Desires position with manufacturing or construction company. Apply through the Society.

112 Member; electrical and mechanical engineer, has had wide experience, building, managing, and operating electrical and cement plants; last five years in active management of cement plant in Middle West; can give best of references East and West. Will go anywhere.

113 Junior member, age 31, single, graduate in mechanical and electrical engineering departments of large technical school, desires to make connection with firm where industry, capacity, and conscientiousness will be appreciated and rewarded. Applicant has ten years' experience in operating, designing and constructing substations, designing steel towers, selling small gas engines, city railway work. Can give best of references, and will start at a reasonable salary.

114 Teacher of mechanical engineering subjects in an eastern university desires a change of location. Ten years experience. College work preferred. Salary $2000 to start.

115 Member, sales agent with established office in New York City, thoroughly acquainted with mechanical and electrical equipments for manufacturing plants, broad acquaintance among architects, engineers and plant-managers, desires to correspond with manufacturers of standing to act as their representative in New York and Eastern territory.

116 Junior member, 27, desires position as scale inspector or designer. Has had extensive experience with railroad track, wagon, and platform scales both as designer and sealer. Had responsible charge of scales in large plants; at present engaged in design and construction of scales. Location immaterial.

117 Member, technical graduate, 31 years of age, desires position as works manager, mechanical superintendent or efficiency expert with company of consulting engineers or large manufacturing corporation; extensive training and experience in central power station work, designing, purchas-

ing, superintending construction and operating departments; consulting engineering work on large properties; power production investigations; cost reduction, experienced in mill and reinforced concrete construction work; at present employed and desires a change for advancement.

118 Mechanical engineer with complete experience from shop apprentice to agency manager wants position as assistant manager, assistant superintendent or production man; faultless record; now employed. Thorough experience in design of well-known, successful and high-grade suction gas producers and engines, Corliss engines and complete power plants; also transmission and special machinery and sales of same. On production work might consider small drawing account with bonus based on reduction made in costs.

119 Mechanical engineer, technical graduate, age 27, married; four years' experience in power plant, efficiency and construction work, desires a position with reliable concern in the East with chance for advancement. At present employed.

120 Works manager or engineer, member, graduate M.E., experienced mechanic, with broad experience here as well as abroad in the design and manufacture of automobiles and motors. Executive ability coupled with efficiency and thoroughness. At present is an engineer with automobile factory. Desires position which offers an opportunity for wider field and greater activity.

121 Junior member, at present employed, desires to change position in order to better opportunity. Two years' experience in large steel works engineering department. Two years mechanical engineer and assistant superintendent of electric company in charge of construction work, building power plants; entire charge of engineering and construction departments. Machinist, thoroughly familiar with all kinds of machinery. Experimental engineer and thorough business training. Competent in estimating, designing and erection. Desires position as superintendent or chief engineer with responsibility and chance for advancement. Would consider position with engineering concern or with consulting engineer.

122 Member; mechanical engineering graduate; age 33; wishes a responsible position as teacher, preferably of laboratory subjects. At present holds such a position, but desires one of greater opportunities. Experience: Four years in shops and drafting rooms, eight years teaching a wide range of mechanical engineering subjects, also experience in research work and as consulting engineer. Can give best of references.

123 Industrial engineer, Junior member, college and technical graduate, five years' experience, desires position with concern contemplating installation of modern and systematic methods of manufacturing or starting the manufacture of a new product; can handle men and get results. At present and for the past three years employed as an industrial engineer by a large eastern manufacturing corporation; work nearing completion, therefore desires to establish new and permanent connection with manufacturers desiring executive of energy and ability.

124 Member, technical graduate, 1907; 29 years old; married; at present employed as superintendent and master mechanic. Experienced in cement business, iron and brass foundry practice, pattern making and machine shop practice, forge and smelting shop work; also experienced in boiler practice and steam engineering. Salary no object provided there is chance for advancement. Particulars of past experience on request as well as references if desired.

125 Position as superintendent or operating executive with electric railway or lighting and power company or bankers controlling such properties. Broad gaged, diplomatic, with good address and attractive personality combined with wide experience and proven ability in developing new business, eliminating troubles and reducing power costs. Six years of shop and road experience with large manufacturer of steam turbines and electrical apparatus. Five years as superintendent of power with large interurban railway and power company. Accustomed to handling customers' complaints, organizing and directing employees, specifying and purchasing equipment and materials. At present assistant to the electrical engineer of a 60,000-kw. power system.

126 Member, with exceptional technical training, both mechanical and electrical; five years' experience in research work on steam turbines, centrifugal air compressors and jet pumps; four years complete charge of designing, manufacturing, testing and installing vacuum cleaner systems, including the development of a complete line of portable and stationary vacuum cleaning machines; desires position with a good firm of consulting engineers, with prospect of ultimate interest in the firm; or would consider position with good manufacturing firm. At present employed.

127 Junior member, aged 27, technical graduate in mechanical engineering, married; four years' experience in factory maintenance, industrial and power plant development, design of special machinery; desires position with an engineering firm or industrial plant.

128 Member, desires position as works manager, superintendent or engineer; competent to organize all departments of manufacturing plant along modern lines; long experience; best references. Expert in developing new inventions.

129 Technical graduate; Junior member; age 30; desires position. Six years' experience teaching in an eastern technical school and in evening industrial school work. Experienced in drafting and general engineering. Energetic and enthusiastic. Would be valuable as director of industrial school, either existing school or to organize a proposed school. Would consider teaching or practice.

130 Technical graduate. Practical experience in foundries, machine shop, drafting rooms and as mechanical engineer for large manufacturing concern having charge of entire upkeep of factory, all electrical work, purchase of supplies, new work, etc. Designed and installed new power plant which is now running and had charge of all work in connection with large new factory building. Desires position with large manufacturing concern or consulting engineer. Advancement to be governed by results.

131 Mechanical engineering graduate of Lehigh University; four years in design, installation and office experience. For the past two years employed in responsible position with maintenance department of a large industrial concern. Has reached the limit of present opportunity. Desires a position with broader outlook. Age 25, married. Location immaterial. Best references.

132 Member, technical graduate, experienced as general or business manager, sales engineer and executive, desires position with manufacturing concern or as representative in New York City. Has many years' experience in foundry and machine shop practice. Broad acquaintance in the engineering, contracting and manufacturing field.

133 Technical graduate; four months as draftsman for tap and die company; 14 months with prominent automobile company in drafting room, shop and factory.

134 Mechanical engineer, graduate of Columbia University, 1911; several years' experience as factory inspector; desires position where there is good chance for advancement. Age 25.

135 Graduate engineer, five years' experience structural work, draftsman on special machinery, and inspector on outside construction; desires position along similar lines.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary Am. Soc. M. E.

Les Accessoires de l'Automobile, F. Carlès. *Paris, 1913.*

American Chamber of Commerce in Paris. Bul. no. 121, January 1914. *Paris, 1914.* Gift of Calvin W. Rice.

The American Office, J. W. Schulze. *New York, 1913.*

The American Society of Mechanical Engineers. Condensed Catalogues of Mechanical Equipment, 1913. 3rd annual volume. *New York, 1913.*

The American Society of Mechanical Engineers. Contents and General Index of Transactions, vols. 1-20, 1880-1899. *New York, 1899.*

American Society of Naval Engineers. General Index to Journal, vols. 1-16, 1889-1904. *Washington, 1905.* Gift of society.

American Water Works Association. Minutes of Proceedings of 33d annual convention, 1913. *1913.* Gift of association.

Association of Harvard Engineers. Year Book, 1913. *1913.* Gift of Calvin W. Rice.

Australia. Parliamentary Debates. Session 1913. nos. 32, 33. *Melbourne.*

Balancing of Engines, W. E. Dalby. ed. 2. *London, 1906.*

Beiträge zur Geschichte der Technik und Industrie, Conrad Matschoss. vol. 5. *Berlin, 1913.*

Boston. Transit Commission. 19th Annual Report, 1913. *Boston, 1913.* Gift of the commission.

Carnegie Institution of Washington. Year Book, 1908-1913. *Washington, 1909-1913.* Gift of institution.

Chicago. Department of Smoke Inspection. Report, February 1912.

——— Notes on Smoke Abatement, January 1, 1914.

——— Methods of Approaching the Smoke Problem. January 1, 1914. Gift of department.

Cranes and Hoists, Hermann Wilda. Translated from the German by Chas. Salter. *London, 1913.* Gift of Hunt Memorial Fund.

Depreciation of Railroad Property, Richard J. McCarty. *Kansas City, 1914.* Gift of author.

Effect of Brakes upon Railway Trains, Douglas Galton. *Pittsburgh, 1894.* Gift of S. W. Dudley.

Die Eis und Kälteerzeugungs Maschinen, Richard Stetefeld. *Stuttgart, 1912.*

Das Entwerfen und Berechnen der Verbrennungskraftmaschinen und Kraftgas-Anlagen, Hugo Güldner. ed. 3. *Berlin, 1914.*

Extension of the Dewey Decimal System of Classification applied to the Engineering Industries, L. P. Breckenridge and G. A. Goodenough. *Urbana, 1912.*

Forscherarbeiten auf dem Gebiete des Eisenbetons. pt. 22. *Berlin, 1914.*

Gas and Coal Dust Firing, Albert Pütsch. Translated from the German by Charles Salter. *London, 1901.*

Die geistigen Mittel des technischen Fortschrittes in den Vereingten Staaten von Amerika, Conrad Matschoss. *Berlin, 1913.* Gift of author.

Handbook of English for Engineers, W. O. Syphers. *Chicago, 1913.*

Horse, Truck and Tractor, H. N. Casson, R. W. Hutchinson, Jr., and L. W. Ellis. *Chicago, 1913.*

Investigating an Industry, William Kent, with an introduction by H. L. Gantt. *New York, 1914.*

Jahrbuch der Luft Fahrzeug Gesellschaft. vol. 6, 1912-1913. *Berlin, 1913.*

Konstruieren und Rechnen, H. Haeder. ed. 6, vols. 1-2. *Wiesbaden, 1914.*

Logging, the Principles and General Methods of Operation in the United States, R. C. Bryant. *New York, 1913.*

Machinery's Handbook. *New York, 1914.*

Manchester Steam Users' Association. Memorandum by Chief Engineer, 1912. *Manchester, 1913.* Gift of association.

Manufacture of Rubber Goods, Adolf Heil and W. Esch. *London, 1909.*

Metal Spinning, F. D. Crawshaw. *Chicago, 1909.*

Metallographie, W. Guertler. vol. 1, sect. 2, pt. 1. *Berlin, 1913.*

Metropolitan Sewerage Commission of New York. Preliminary Reports on the Disposal of New York's Sewage. VIII—Tidal Currents in New York Harbor as shown by floats, October 1913. IX—Rainfall and the relations between the volumes of domestic sewage, storm water and tidal water in New York Harbor, November 1913. Gift of commission.

Le Moteur Humain et les bases scientifiques du travail professionnel, Jules Amar. *Paris, 1914.*

Motion Picture Handbook, F. H. Richardson. ed. 2. *New York, 1912.*

National Association of Railway Commissioners. Proc. 25th Annual Convention, Washington, October 28-31, 1913. *New York, 1913.*

Neuere probleme der Theoretischen Physik. Columbia University. Publication no. 7, Ernest Kempton Adams Fund for Physical Research. *Leipzig-Berlin, 1913.* Gift of Columbia University.

New Steam Tables together with their derivation and application, C. A. M. Smith and A. G. Warren. *New York, 1912.*

New York City. Board of Water Supply. Catskill Water Supply, reports, letters, resolutions and authorizations on the City tunnel and the delivery of Catskill water. *New York City, 1912.* Gift of board.

New York City. Department of Water Supply, Gas and Electricity Bureau of Supplies. A report to Henry S. Thompson, Commissioner, by Elihu Cunyngham Church. *New York, 1913.* Gift of E. C. Church.

New York State. Commission of Highways. Report of the Board of Consulting Engineers, 1913. *Albany, 1913.* Gift of William DeHertburn Washington.

New York State Engineer and Surveyor. Supplement to the Annual Report, 1912, vol. 2. *Albany, 1913.* Gift of State Engineer and Surveyor.

Official Congressional Directory, 63d Congress, 2d Session, December 1913. *Washington, 1913.* Gift of U. S. Congress.

Oxy-Acetylene Torch Practice, J. F. Springer. *New York.*

Pennsylvania Railroad Company. Brake Tests. A report of a series of road tests of brakes on passenger equipment cars made at Absecon, N. J., 1913. *Altoona, 1913.* Gift of railroad company.

Physikalische Chemie der homogenen und heterogenen Gasreaktionen, Karl Jellinek. *Leipzig, 1913.*

Poor's Manual of Railroads, 1914. *New York, 1914.*

La Pratique des Moteurs Diesel, description conduite, incidents de Marche, Jean Lorfèvre. *Paris, 1914.*

Progress and Prosperity, William DeHertburn Washington. *New York, National Educational Publishing Co., 1911.* Gift of author.

The purpose of this work is to portray the evolution of transportation and the tremendous effects it has wrought in the progress and prosperity of mankind and communities. The author, after emphasizing how essential a factor transportation was even to primitive civilization, takes up the story of carriage in ancient mediaeval and early modern times, and shows how nations rose into prominence with the control of routes of communication, and fell into decay with their loss.

The organization, operation, and influence of transportation systems, both in the United States and abroad, are depicted, and numberless striking facts are brought out which bear directly upon present-day problems.

PRÜFUNG UND BERECHNUNG AUSGEFÜHRTER AMMONIAK-KOMPRESSIONS KÄLTEMASCHINEN AN HAND DES INDIKATOR-DIAGRAMMES, Gustav Döderlein. ed. 2. *München, 1910.*

REARRANGEMENT AND DEVELOPMENT OF THE STEAM RAILROAD TERMINALS OF THE CITY OF CHICAGO, REPORT, B. J. Arnold. *Chicago, 1913.* Gift of author.

RULES, REGULATIONS AND INSTRUCTIONS FOR FOREMEN AND DEPARTMENT HEADS OF A. J. LINDEMANN & HOVERSON CO. BY THE SAFETY COMMITTEE. *Milwaukee, 1913.* Gift of company.

SAFETY VALVE CAPACITY, P. G. Darling. *New York.* Gift of Manning, Maxwell & Moore.

SCHNELL-PERSPEKTIVE UND EINFÜHRUNG IN DAS TECHNISCHE ZEICHNEN, O. Haeder. ed. 2. *Wiesbaden, 1914.*

SOME FACTS ABOUT TREATING RAILROAD TIES, W. F. Goltra. pts. 1-4. *Cleveland, 1912-1913.*

DIE STABILITÄT DER FLUGZEUGE, G. H. Bryan. Translated into English by H. G. Bader. *Berlin, 1914.*

DIE STATIK DES KRANBAUES, W. L. Andrée. ed. 2. *München, 1913.* Gift of Hunt Memorial Fund.

STATISTIK DER STEINKOHLENGASWERKE, L. Molnár and I. Pfeifer. In German and Hungarian. *Budapest, Dick Manó Kiadása, 1913.*

STRÖMUNGSENERGIE UND MECHANISCHE ARBEIT, Paul Wagner. *Berlin, 1914.*

TAN BARK AS A BOILER FUEL, David Moffat Myers. Gift of author.

TRANSMISSIONEN, Stephan Jellinek. *Berlin, 1912.*

TURBINEN MIT DAMPFENTNAHME EIN BEITRAG ZUR BERECHNUNG DER ANZAPFTURBINEN, Aug. Kriegbaum. *München, 1913.*

U. S. LIGHTHOUSE COMMISSIONER. Annual Report to the Secretary of Commerce for the year ended June 30, 1913. *Washington, 1913.* Gift of commissioner.

VACUUM CLEANING SYSTEMS. A treatise on the principles and practice of mechanical cleaning, M. S. Cooley. *New York, 1913.*

VALVES AND VALVE GEAR MECHANISMS, W. E. Dalby. *London, 1906.*

LA VIE INTERNATIONALE. vol. 1, nos. 1-5; vol. 2, nos. 1, 7-8; vol. 3, nos. 1-6; vol. 4, no. 1. *Bruxelles, 1912-1913.* Gift of Office Central des Association Internationales.

CLEMENS WINKLER'S VORTRÄGE UND ABHANDLUNGEN ÜBER ABGASE UND RAUCHSCHÄDEN, O. Brunck. Sammlung von Abhandlungen über Abgase und Rauchschäden, pt. 8. *Berlin, 1913.*

WORK, WAGES AND PROFITS, H. L. Gantt. ed. 2. *New York, Engineering Magazine Co., 1913.* Gift of F. M. Griswold.

The first edition, published in 1910, was a small volume of less than two hundred pages. This second edition has over three hundred pages with much new matter, embodying results in machine shops, metal-working and locomotive building plants.

FIRE INSURANCE ENGINEERING. An address delivered by F. M. Griswold, before Fire Insurance Society of Philadelphia, February 21, 1905.

FIRE PREVENTION AND FIRE PROTECTION FOR MANUFACTURING PLANTS. *May 1911.*

STANDARDS FOR GRADING TOWN PUBLIC FIRE PROTECTION. Report of a Committee of the National Fire Protection Association, October 29, 1903.

GIFT OF NEW YORK STATE CONSERVATION COMMISSION

ANNUAL REPORT. 2d-3d. 1912-1913. *Albany, 1912-1913.*

ANNUAL REPORT—DIVISION OF INLAND WATERS. 1st-2d. *Albany, 1912-1913.*

CHEAP ELECTRICITY FOR ALL

CIRCULAR OF INFORMATION PUBLISHED FOR DISTRIBUTION AT THE NEW YORK STATE FAIR, Syracuse, September 11-16, 1911.

FINAL ORDER FOR THE REGULATION OF THE FLOW OF THE HUDSON RIVER, etc. *Albany, 1911.*

FISHWAYS FOR DAMS, 1912. *Albany, 1912.*

NEW YORK'S WATER SUPPLY AND ITS CONSERVATION, DISTRIBUTION AND USES.

PURE WATER AND PLENTY OF IT IN EVERY HOME AND FACTORY

REPORT OF THE CONSERVATION COMMISSION ON THE WATERSHED OF THE GENESEE. *Albany, 1912.*

REPORT OF THE CONSERVATION COMMISSION TO THE LEGISLATURE OF THE STATE OF NEW YORK ON THE SUBJECT OF HIGH AND LOW WATER IN LAKE GEORGE. *Albany, 1913.*

STATE DEVELOPMENT OF ELECTRICAL ENERGY. Address delivered by Geo. E. Van Kennen. *Albany, 1912.*

STATE DEVELOPMENT OF WATER POWER. *Albany, 1912.*

STATE HYDRO-ELECTRIC DEVELOPMENT. Why the Murtaugh-Patrie bill should become a law. *Albany, 1913.*

WATER POWER FOR THE FARM AND COUNTRY HOME, D. R. Cooper. ed. 2.

WATER RESOURCES OF THE STATE OF NEW YORK, H. H. Persons. *Albany, 1910.*

DIVISION OF INLAND WATERS. Rules and Regulations governing Sewerage Applications. *Albany, 1912.*

—— Rules and regulations governing water supply applications. *Albany, 1912.*

EXCHANGES

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION. Report of Proc. 46th Annual Convention. *Chicago, 1913.*

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS. Trans., vol. 18, 1912. *New York, 1913.*

JUNIOR INSTITUTION OF ENGINEERS. Journal and Record of Trans., vol. 22, 1912-1913. *London, 1913.*

KONINKLIJK INSTITUUT VAN INGENIEURS. Yearbook, 1914. *'s-Gravenhage, 1914.*

MASTER CAR BUILDERS' ASSOCIATION. Proc., vol. 47, pts. 1-2, 1913. *Chicago, 1913.*

U. S. PATENT OFFICE. Annual Report of the Commissioner of Patents, 1912. *Washington, 1913.*

NATIONAL ASSOCIATION OF COTTON MANUFACTURERS. Trans., no. 91, 93, 94. *Boston, 1912-1913.*

SOCIETY OF AUTOMOBILE ENGINEERS. Trans., vol. 8, pt. 2. *New York, 1913.*

UNIVERSITY OF ILLINOIS ENGINEERING EXPERIMENT STATION. bul. vol. 8-9, 1912-1913. *Urbana, 1913.*

UNITED ENGINEERING SOCIETY

AMERICAN YEAR BOOK, 1913. *New York, 1914.*

ENGINEERING INDEX, 1913. *New York, 1914.*

AN EXPENSIVE EXPERIMENT. The Hydro-electric Power Commission of Ontario, R. P. Bolton. *New York, 1913.* Gift of author.

METAL STATISTICS, 1914. ed. 7. *New York, American Metal Market Co., 1914.*

MICHIGAN GAS ASSOCIATION. Proc. 22d Annual Meeting, 1913. *1913.* Gift of association.

NATIONAL TUBE COMPANY. BOOK OF STANDARDS, 1913. *Pittsburgh, 1913.* Gift of company.

NEW YORK TIMES INDEX, October-December 1913. *New York, 1913.*

REFERENCE CATALOGUE OF CURRENT LITERATURE. 3 vols. *London, J. Whitaker & Sons, 1913.*

UNIVERSAL ELEMENTS AND THEIR PRIME COMBINATIONS, Julius L. Hornig. *Jersey City, 1913.* Gift of author.

UNIVERSITY OF CALIFORNIA. List of Serials in the Library

(Library Bulletin no. 18). *Berkeley, 1913.* Gift of University of California.

THE WORLD ALMANAC, 1914. *New York, 1914.*

TRADE CATALOGUES

GOLDSCHMIDT-THERMIT CO., *New York.* Reactions, vol. 6, no. 4, 1913.

HESS-BRIGHT MFG. CO., *Philadelphia, Pa.* Ball bearings and their correct use, ser. 336, sheets 1-59.

HUMPHREY GAS PUMP CO., *Syracuse, N. Y.* Type W pumps.

HEATING COSTS

List of References compiled in the Library of the Engineering Societies.

OPERATING COSTS IN HEATING PLANTS. Analyses of cost of heating various classes of buildings with steam and hot water heating systems. *Metal Worker*, November 14, 1913, pp. 579-581; *Power*, September 23, 1913, pp. 437-438. Abstract of paper read by H. M. Hart before the American Society of Heating and Ventilating Engineers.

ANALYSIS OF MOTOR SERVICE AND HEATING COSTS IN A JEWELRY FACTORY. *Electrical World*, vol. 61, pp. 1369-1370, June 21, 1913. Discusses the cost of steam.

ECONOMICS OF CENTRAL STATION HEATING, Byron T. Gifford. *American Society of Mechanical Engineers, Journal*, September 1913, pp. 1421-1425. A generation cost of 30 cents per 1000 lbs. is assumed.

THE DESIGN OF CENTRAL HEATING SYSTEMS, A. G. Christie. *Canadian Engineer*, July 17, 24, 31, 1913. Discusses cost of laying conduits, also rates charged for service.

DISTRICT STEAM HEATING WITH HIGH PRESSURE STEAM, Frederick W. Ballard. *Ohio Society of Mechanical, Electrical and Steam Engineers, Journal*, vol. 5, pp. 25-37, 1913. Reprinted in *Heating and Ventilating Magazine*, June 1913, pp. 21-28. Abstract in *Power*, June 3, 1913, pp. 783-786. Gives tables showing comparative cost of installation of high and low pressure mains.

NOTES FROM A DATA BOOK ON FACTORY HEATING. *Heating and Ventilating Magazine*, May 1913, pp. 37-38. Abstract of paper by Wallace F. Goodnow before the New York Chapter of the American Society of Heating and Ventilating Engineers.

THE ORIGIN AND COMPARATIVE COST OF THE TRUNK LINE SYSTEM, F. D. Goodard. *Metal Worker*, vol. 74, p. 171, August 6, 1910.

THE PROFITABLE OPERATION OF CENTRAL HEATING STATION WITHOUT THE ASSISTANCE OF ELECTRICAL OR OTHER INDUSTRIES, Byron T. Gifford. *Heating and Ventilating Magazine*, August 1910, pp. 10-13; discussion pp. 13-14. Paper read before National District Heating Association.

SOME NOTES ON ISOLATED PLANTS, Percival R. Moses. *American Institute of Electrical Engineers*, January 1912, pp. 67-98. Gives cost of fuel and labor for heating in typical building without private electric plants.

HIGH PRESSURE STEAM HEATING VS. HOT WATER BY-PRODUCT PLANT, Ira N. Evans. *Power*, July 29, 1913, pp. 169-172.

EXHAUST STEAM HEATING AS DEVELOPED BY A LARGE CENTRAL LIGHTING STATION, E. Darrow. *Electrical World*, vol. 57, pp. 859-61, 1911.

WILKES-BARRE'S DISTRICT HEATING SYSTEM. Donald M. Belcher. *Engineering Record*, vol. 66, pp. 300-302, 1912. Construction and cost of installing heat-insulated mains underground.

HOT WATER HEATING FOR THE CENTRAL STATION, Ira N. Evans. *Power*, vol. 35, pp. 625-628, 1912. Gives cost of coal.

COMPARATIVE ECONOMY OF CENTRAL AND PRIVATE HEATING PLANTS, J. D. Hoffman. *Heating and Ventilating Magazine*, June 1910, pp. 6-14.

DATA ON CENTRAL HEATING STATIONS. *Heating and Ventilating Magazine*, November 1909, pp. 7-10. Tables show cost per year for repairs, etc., also cost of coal.

ANALYSIS OF CENTRAL STATION STEAM HEATING RATES, A. E. Duram. *Heating and Ventilating Magazine*, September 1912, pp. 11-17.

CENTRAL STATION HEATING, Byron T. Gifford. *Heating and Ventilating Magazine*, June 1911, October 1911.

SOME NOTES ON CENTRAL HEATING, William H. Bryan. *American Society of Heating and Ventilating Engineers, Trans.*, vol. 7, pp. 97-117; discussion, pp. 117-131, 1901.

COMPARISON OF FORCED CIRCULATION HOT WATER AND VACUUM STEAM CENTRAL HEATING SYSTEMS, J. T. Maguire. *Engineering News*, vol. 62, pp. 692-693, 1909. First cost operating expense.

SOME OF THE FACTORS THAT AFFECT THE COST OF GENERATING AND DISTRIBUTING STEAM FOR HEATING, C. R. Bishop. *Engineering Review* (N. Y.), August 1910, pp. 56-60. Paper read before National District Heating Association. The author does not give figures, but discusses the subject generally.

SOME FACTS AND A FEW THEORIES CONCERNING THE OPERATION OF A CENTRAL STATION HOT WATER HEATING AND ELECTRICAL GENERATING PLANT, J. D. Hoffman. *Heating and Ventilating Magazine*, October 1908, pp. 1-6.

EXHAUST STEAM—ITS PLACE IN A DIVISION OF THE COST OF SERVICES IN BUILDINGS, Reginald P. Botton. *Heating and Ventilating Magazine*, October 1908, pp. 17-21. Discussion at a convention of building managers.

RELATIVE ECONOMY OF STEAM AND GAS POWER WHEN EXHAUST STEAM IS USED FOR HEATING, F. W. Ballard. *Heating and Ventilating Magazine*, September 1907, pp. 31-34. From paper read before the Ohio Society of Mechanical, Electrical and Stationary Engineers.

OPERATING COSTS OF A DEPARTMENT STORE, S. Milton Clark. *Isolated Plant*, February 1913, pp. 71-73. Detailed cost of plant in Bonwit, Teller & Company's department store.

THE CENTRAL HEATING AND ELECTRIC LIGHTING STATION AT DRESDEN. *Engineer* (Lond), vol. 100, pp. 330, 358, 1905; *Engineering Record*, vol. 52, p. 582, 1905. Gives cost of coal.

UEBER DIE BETRIEBSERGEBNISSE DES KGL. FERNHEIZ UND ELEKTRIZITÄTSWERKES ZU DRESDEN, B. Trautmann. *Gesundheits Ingenieur*, June 2, 1907. Gives costs and details of operating a central plant for heating and lighting a group of municipal buildings.

COST OF HEATING RESIDENCES, J. D. Hoffman. *Metal Worker*, vol. 69, pp. 48-49, 1908. Paper read before Indiana Engineering Society.

COST OF EXHAUST STEAM HEATING, Ira N. Evans. *Power*, vol. 36, pp. 788-792, 1912.

COST OF HEATING STORE HOUSES, H. O. Lacount. *American Society of Mechanical Engineers*, vol. 29, pp. 159-195; discussion, pp. 195-202, 1907.

HEATING AND VENTILATION OF THE ST. LOUIS PUBLIC SCHOOL BUILDINGS, William B. Ittner. *Heating and Ventilating Magazine*, December 1907, pp. 6-10. Gives fuel costs.

SOME INTERESTING AND COMPLETE FIGURES, Ernest Stevens. *Isolated Plant*, May 1912, pp. 190-194. The cost of heating is given in a record of one year's operation of the Boston Safe Deposit and Trust Company Building plant.

ISOLATED PLANT VS. CENTRAL STATION. *Isolated Plant*, April 1912, p. 109. Abstract of paper read by David S. Boyden before the American Society of Heating and Ventilating Engineers.

WHY THE ISOLATED PLANT MOVEMENT SHOULD BE SUPPORTED, Arthur V. Farr. *Isolated Plant*, January 1912, pp. 23-

25. An estimate of the cost of operation of a heating plant.

CENTRAL STATION STEAM HEATING, A. S. Spencer. *Power*, vol. 32, pp. 1198-1199, July 5, 1910. Operating costs are given.

BOOKS

CARPENTER, ROLLA C. Heating and Ventilating Buildings. Ed. 5. *New York, J. Wiley, 1911.*

GIFFORD, BYRON T. Central Station Heating. *New York, Heating and Ventilating Magazine Co., 1913*, pp. 81-83.

GREENE, ARTHUR M. The Elements of Heating and Ventilation; a text book for students, engineers and architects. *New York, Wiley, 1913.* Chapter 11—District Heating.

HOFFMAN, JAMES D., AND RABER, BENEDICT F. Handbook for Heating and Ventilating Engineers. Ed. 2. *New York, McGraw-Hill Book Co., 1913.* Cost of heating from a central station, pp. 258-263.

KING, ALFRED G. Practical Steam and Hot Water Heating and Ventilation. *New York, Henley Pub. Co., 1908*, pp. 255-257.

RANDALL, D. T., AND WEEKS, H. W. The Smokeless Combustion of Coal in Boiler Furnaces, with a chapter on Central Heating Plants (reprint of U. S. Geol. Survey Bull. no. 373, revised by Henry Kreisinger). U. S. Bureau of Mines. Bulletin no. 40.

SUN MOTORS

UTILIZING THE ENERGY OF SOLAR RADIATION, THE WIND, AND OTHER INTERMITTENT NATURAL RESOURCES, R. A. Fessenden. *Mechanical Engineer*, vol. 26, pp. 586-588, November 4, 1910; *Electrician* (Lond.), vol. 65, pp. 948-949, September 16, 1910. Paper read before Section G of the British Association for the Advancement of Science.

A NEW PROPOSAL TO SECURE POWER ON A LARGE SCALE FROM INTERMITTENT NATURAL RESOURCES. *Engineering News*, vol. 64, pp. 539-540, November 17, 1910. Editorial discussion of the plan outlined by Prof. R. A. Fessenden.

POWER FROM THE SUN'S HEAT. *Engineering News*, May 13, 1909, vol. 61, pp. 509-511. Abstract in *Engineering Review* (Lond), vol. 21, pp 57-62, 1909; *Engineering Digest*, July 1909, pp. 1-5.

EXPERIMENTS IN THE DEVELOPMENT OF POWER FROM THE SUN'S HEAT, H. E. Wilsie. *Engineering News*, vol. 61, pp. 511-514, May 13, 1909; editorial, p. 522.

SOLAR MOTOR. *Railway and Engineering Review*, vol. 41, p. 103, February 23, 1901.

DESCRIPTION OF THE PHILADELPHIA SUN POWER PLANT. *Engineering News*, September 21, 1911, p. 327.

SOLAR MOTORS, Chas. F. Holder. *Scientific American*, vol. 84, pp. 169-170, March 16, 1901.

SOLAR PUMPING PLANT. *Metal Worker*, October 6, 1911, p. 450.

COMMERCIAL SUN POWER PLANT. *Engineering Record*, September 23, 1911, p. 368.

PRODUCING POWER FROM THE SUN'S RAYS, A. D. Blake. *Power*, October 3, 1911, p. 506.

L'UTILISATION DE LA CHALEUR SOLAIRE À LA PRODUCTION DE LA FORCE MOTRICE GÉNIE CIVIL, vol. 60, pp. 13-14.

POWER FROM THE SUN. *Mechanical Engineer*, vol. 27, p. 307. Abstract of lecture by J. J. Thomson before the Royal Institution.

UTILIZZAZIONE DEL CALORI DEI RAGGI SOLARI. *L'Elettricista*, March 1, 1912, p. 79.

ALST. *Engineering News*, vol. 67, pp. 1077-1079, June 6, 1912. Report on Shuman Engine, commercially used for irrigation in Egypt.

INVESTIGATION OF THE ECONOMY OF A SIMPLE ENGINE OPERATING WITH STEAM LESS THAN THAT OF ATMOSPHERIC PRESSURE, Prof. R. C. Carpenter. *Sibley Journal*, vol. 26, pp. 293-311, April 1912.

SUN-POWER PLANT, Frank Shuman. Pract. Engr. (chic.), August 15, 1912, p. 825.

SUN MOTORS, K. T. B. Tressler. *Indian Trade Journal*, vol. 25, pp. 90-91, 1912. (1/5 the surface required by Shuman).

THE SHUMAN-HAINES STEAM ENGINE, May 30, 1913, pp. 574-576. *Sw. Amer. Suppl.*, November 7, 167, 422, 663.

SOLAR PUMPING PLANT. *Iron Age*, vol. 88, pp. 698-699, September 28, 1911 (Shuman engine).

SUN POWER STEAM ENGINE. *Iron Age*, vol. 89, p. 1490, June 13, 1912. Paragraph summarizing the results of Professor Carpenter's tests.

THE UTILIZATION OF SOLAR HEAT FOR INDUSTRIAL PURPOSES BY MEANS OF A NEW PLANE MIRROR REFLECTOR, Carl Güntner. *Scientific American Suppl.*, vol. 61, pp. 25409-25412, 1906.

SOLAR ENGINE IN EGYPT. *Scientific American*, December 7, 1912, p. 481. Letter by Frank Shuman.

Illustrated London News, March 15, 1913, p. 338. Description of Shuman Installation in Egypt.

THE SUN POWER PLANT REFLECTORS AND GENERATORS IN EGYPT, Frank C. Perkins. *Isolated Plant*, October 1913, pp. 19-23.

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International Engineering Congress 1915
The President, The Secretary, W. F. Durand, E. C. Jones, T. W. Ransom, C. R. Weymouth

National Museum
E. D. Meier, *Chairman;* G. F. Kunz, George Mesta, H. G. Reist, Ambrose Swasey

Changes in the Patent Laws of United States
W. H. Blauvelt, C. C. Thomas, Edward Weston, W. E. Winship, B. F. Wood

Pipe Thread Gages
E. D. Meier, *Chairman;* George M. Bond, A. M. Houser, J. C. Meloon, C. A. Olson, P. C. Patterson, H. G. Stott

International Standard for Pipe Threads
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Power Tests
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William Kent, *Chairman;* J. R. Bibbins, M. L. Cooke, W. B. Snow

Standardization of Filters
G. W. Fuller, *Chairman;* J. C. Boyd, P. N. Engel, J. C. W. Greth, Wm. Schwanhausser

Steam Boilers and Other Pressure Vessels and for Care of Same in Service. Committee to Formulate Standard Specifications for the Construction of
J. A. Stevens, *Chairman;* W. H. Boehm, R. C. Carpenter, Richard Hammond, C. L. Huston, E. D. Meier, E. F. Miller

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Tellers of Election
J. P. Ilsley, *Chairman;* R. T. Kent, R. J. S. Pigott

Tolerances in Screw Thread Fits
L. D. Burlingame, *Chairman;* Ellwood Burdsall, F. G. Coburn, F. H. Colvin, A. A. Fuller, James Hartness, H. M. Leland, W. R. Porter, F. O. Wells, Walter E. Worthington

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Spring Meeting
W. H. Bovey, H. LeR. Brink, Oliver Crosby, Paul Doty, J. J. Flather, J. N. Hannaford, W. H. Kavanaugh, M. Martin, John Mitchell, C. L. Pillsbury, J. L. Record, Max Toltz, R. B. Whitacre

Textiles
C. T. Plunkett, *Chairman;* E. W. Thomas, *Secretary;* D. M. Bates, John Eccles, E. D. France, E. F. Greene, F. W. Hobbs, C. R. Makepeace, C. H. Manning, H. F. Mansfield

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Boston
R. E. Curtis, *Chairman;* W. G. Snow, *Secretary;* H. N. Dawes, C. H. Fish, A. L. Williston

Buffalo
W. H. Carrier, *Chairman;* C. H. Bierbaum, C. A. Booth, S. B. Daugherty, Jas. W. Gibney

Chicago
Paul P. Bird, *Chairman;* C. W. Naylor, *Secretary;* C. R. Birdsey, W. B. Jackson, A. W. Moseley

Cincinnati
A. L. DeLeeuw, *Chairman;* Jas. B. Stanwood, *Vice-Chairman;* J. T. Faig, *Secretary;* W. G. Franz, G. W. Galbraith

Milwaukee
E. P. Worden, *Chairman;* Fred. H. Dorner, *Secretary;* M. A. Beck, Henry Weickel, H. V. Conrad, Henrik Greger, L. P. C. Smith

Minnesota
Max Toltz, *Chairman;* C. L. Pillsbury, *Vice-Chairman;* E. J. Heinen, Wm. H. Kavanaugh, Paul Doty

New Haven
E. S. Cooley, *Chairman;* E. H. Lockwood, *Secretary;* F. L. Bigelow, L. P. Breckenridge, H. B. Sargent

New York
R. V. Wright, *Chairman;* Edward Van Winkle, *Treasurer;* H. R. Cobleigh, *Secretary;* J. J. Swan, J. P. Neff

Philadelphia
D. R. Yarnall, *Chairman;* W. R. Jones, *Secretary;* J. E. Gibson, Lewis H. Kenney, T. C. McBride

San Francisco
Robert Sibley, *Chairman;* Thos. Morrin, *Vice-Chairman;* C. T. Hutchinson, *Secretary;* E. C. Jones, C. R. Weymouth

St. Louis
F. E. Bausch, *Chairman;* E. L. Ohle, *Secretary;* H. Wade Hibbard, John Hunter, L. C. Nordmeyer

SOCIETY REPRESENTATIVES

Council of Amer. Assn. Adv. Science
A. C. Humphreys, W. B. Jackson

Engineering Education
A. C. Humphreys, F. W. Taylor

John Fritz Medal
J. A. Brashear (1), F. R. Hutton (2), J. R. Freeman (3), Ambrose Swasey (4)

General Conference Committee of National Engineering Societies
C. W. Baker, Alfred Noble

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F. R. Hutton

Secretary
Geo. A. Orrok

Gas Power Membership Committee
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Gas Power Executive Committee
C. H. Benjamin (1), W. H. Blauvelt (3), W. D. Ennis (5), H. J. K. Freyn (1), F. R. Low (2), I. E. Moultrop (4), H. H. Suplee (1)

Gas Power Literature Committee
R. B. Bloemeke, *Chairman;* A. W. H. Griepe, W. F. Monaghan, W. S. Morrison, S. I. Oesterreicher, H. G. Wolfe

Gas Power Committee on Meetings
Wm. T. Magruder, *Chairman;* W. H. Blauvelt, E. D. Dreyfus, A. H. Goldingham, Nisbet Latta, H. B. MacFarland

OFFICERS OF AFFILIATED SOCIETY

Providence Association of Mechanical Engineers

W. H. Paine, *President;* Arthur H. Annan, *Vice-Chairman;* J. Ansel Brooks, *Secretary;* A. H. Whatley, *Treasurer*

OFFICERS OF THE STUDENT BRANCHES

INSTITUTION	DATE AUTHORIZED BY COUNCIL	HONORARY CHAIRMAN	CHAIRMAN	CORRESPONDING SECRETARY
Armour Inst. of Tech.	Mar 9, 1909	G. F. Gebhardt	H. E. Erickson	A. N. Koch Armour Inst. of Tech., Chicago, Ill.
Carnegie Inst. of Tech.	Oct 14, 1913	W. Trinks	J. B. Patterson	W. M. Sheldon 226 Meyran Ave., Pittsburgh, Pa.
Case School of Applied Science	Feb 14, 1913	F. H. Vose	H. C. Mummert	J. B. Whitacre Case School of Applied Science, Cleveland, O.
Columbia Univ.	Nov 9, 1909	Chas. E. Lucke	F. B. Schmidt	H. F. Allen Hartley Hall, Columbia Univ., N. Y.
Cornell Univ.	Dec 4, 1908	R. C. Carpenter	J. G. Miller	D. S. Wegg, Jr. Telluride Asso., Ithaca, N. Y.
Kansas State Agri. College	Feb 13, 1914			
Lehigh Univ.	June 2, 1911	P. B. de Schweinitz	W. C. Owen	T. G. Shaffer Die Alte Brauerei, South Bethlehem, Pa.
Leland Stanford Jr. Univ.	Mar 9, 1909	W. F. Durand	C. P. Campbell	B. M. Green Stanford University, Cal.
Mass. Inst. of Tech.	Nov 9, 1909	E. F. Miller	H. W. Treat	L. L. Downing 30 Bowdoin St., Cambridge, Mass.
New York Univ.	Nov 9, 1909	C. E. Houghton		
Ohio State Univ.	Jan 10, 1911	Wm. T. Magruder	R. M. Wagner	C. L. Newby 1425 Hunter Ave., Columbus, O.
Penn. State College	Nov 9, 1909	J. P. Jackson	A. L. Foell	R. W. Herzog Penn. State College, State College, Pa.
Poly. Inst. of Brooklyn	Mar 9, 1909	W. D. Ennis	A. A. Bielek	H. Sand Poly. Inst. of Brooklyn, Brooklyn, N. Y.
Purdue Univ.	Mar 9, 1909	G. A. Young	S. A. Peck	T. S. Tulein Purdue Univ., West Lafayette, Ind.
Rensselaer Poly. Inst.	Dec 9, 1910	A. M. Greene, Jr.	F. E. McMullen	R. L. Manier Y. M. C. A., Troy, N. Y.
State Univ. of Iowa	Apr 11, 1913	R. S. Wilbur	F. H. Guldner	C. S. Thompson 935 E. College St., Iowa City, Ia.
State Univ. of Kentucky	Jan 10, 1911	F. P. Anderson	H. G. Strong	R. T. Thornton R. R. 1., Lexington, Ky.
Stevens Inst. of Tech.	Dec 4, 1908	Alex. C. Humphreys	L. F. Bayer	C. H. Colvin Stevens Inst. of Tech., Hoboken, N. J.
Syracuse Univ.	Dec 3, 1911	W. E. Ninde	G. T. Parsons	W. J. Campbell 303 Waverly Ave., Syracuse, N. Y.
Univ. of Arkansas	Apr 12, 1910	B. N. Wilson	M. McGill	C. Bethel Univ. of Ark., Fayetteville, Ark.
Univ. of California	Feb 13, 1912	Joseph N. LeConte	R. Guillon	P. H. Landon Univ. of Cal., Berkeley, Cal.
Univ. of Cincinnati	Nov 9, 1909	J. T. Faig	A. O. Hurxthal	E. A. Oster 1065 Wade St., Cincinnati, O.
Univ. of Illinois	Nov 9, 1909	W. F. M. Goss	A. H. Aagaard	H. E. Austin Univ. of Illinois, Urbana, Ill.
Univ. of Kansas	Mar 9, 1909	F. H. Sibley	L. C. Angevine	H. L. Newby 1501 Rhode Island St., Lawrence, Kan.
Univ. of Maine	Feb 8, 1910	Arthur C. Jewett	E. E. Fowler	A. B. Hayes S. A. E. House, Orono, Me.
Univ. of Minnesota	May 12, 1913	J. J. Flather	A. Buenger	J. A. Colvin 629 15th Ave., S. E., Minneapolis, Minn.
Univ. of Missouri	Dec 7, 1909	H. Wade Hibbard	R. Runge	L. L. Leach Y. M. C. A. Bldg., Columbia, Mo.
Univ. of Nebraska	Dec 7, 1909	J. D. Hoffman	A. A. Luebs	G. W. Nigh Sta. A. Box 1164, Lincoln, Neb.
Univ. of Wisconsin	Nov 9, 1909	H. J. Thorkelson	M. A. Cook	R. E. Maurer 167 Prospect Ave., Madison, Wis.
Washington Univ.	Mar 10, 1911	E. L. Ohle	A. O. Schleiffarth	J. A. Watkins, Jr. 5803 Michigan Ave., St. Louis, Mo.
Yale Univ.	Oct 11, 1910	L. P. Breckenridge	L. F. Harder	M. C. Corbett 288 Orchard St., New Haven, Conn.

PERSONAL NOTES

A membership pin was recently found in Pittsburgh and is now in the rooms of the Society, where it may be secured by its owner.

At the meeting of the Council on March 13, the Secretary was instructed to convey to George A. Orrok the satisfaction of the Council over the reports of his improving health, and their hope that he may soon be able to take up his former active participation in the Society's affairs.

Prof. F. R. Hutton, Honorary Secretary, delivered an address before the officers of the U. S. Army detailed to the Aviation School of the U. S. Signal Corps, on the morning of March 7. His topic was the Line of Responsibility of the Designer and Operator of the Internal-Combustion Motor, and the meeting was held in the hangars of the post on North Island, San Diego Harbor, Cal.

George K. Miltenberger, formerly general manager of the Fulton Electric Light and Power Company, Fulton, Ky., has become associated with the Perry County Public Utilities Company, of Perryville, Mo.

W. E. Winship has accepted the position of general manager of the Titan Storage Battery Company, Newark, N. J. He was until recently connected with the Adamant Battery Company, Boston, Mass., in the capacity of vice-president.

W. M. Bosworth has been appointed mechanical engineer of the Louisville and Nashville Railroad Company, with headquarters at South Louisville, Ky. Mr. Bosworth was, until recently, associated with the Kansas City Southern Railway Company, Pittsburg, Kansas, in the same capacity.

Russell W. Stovel, formerly connected with Westinghouse, Church, Kerr & Company, New York, as managing engineer, has become identified with Gibbs & Hill, Consulting Engineers, New York.

George J. Gauthier has severed his connection with the Trinidad Electric Transmission Railway and Gas Company, of Trinidad, Colo., and has become associated with Messrs. Allan and Jones under the firm name of Gauthier, Allan & Jones, with headquarters in Minneapolis, Minn.

H. Howell Wilson has become associated with the United Gas and Electric Engineering Corporation as engineer of power stations of the American Gas and Electric Engineering Corporation, with headquarters in New York. Mr. Wilson was, until recently, superintendent of power plants of the Baltimore & Ohio Railroad Company, Baltimore, Md.

Peter Eyermann, formerly engineer of construction of the Witkowitz Steel Works, Witkowitz, Austria, has been appointed general superintendent of the new Austrian Steel Industry Company, Brux, Bohemia, Austria.

Willard H. Cobb has become identified with the manufacturing department of the New York Belting and Packing Company, New York. He was formerly assistant engineer of Westinghouse, Church, Kerr & Company, New York.

J. W. Sheperdson, assistant chief engineer of the Cambria Steel Company, Johnstown, Pa., has resigned to accept the position of assistant general superintendent of the Central Iron & Steel Company, Harrisburg, Pa.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

At a meeting of the Armour Institute of Technology Student Branch on March 4, the following officers were elected for the coming year: F. L. Brewer, Jr., president; A. A. Anderson, vice-president; J. A. Agee, secretary; W. L. Juttemeyer, treasurer. Oscar Goetz (1914) gave a talk on Kerosene Carburation, and Lyman Close (1915) on Vehicle Springs.

COLUMBIA UNIVERSITY

A meeting of the Mechanical Engineering Society of Columbia University on February 19 was addressed by two of the student members, R. P. Piperoux (1914) and H. F. Allen (1915). Mr. Allen gave an account of his summer shop experiences at the Cooke Works of the American Locomotive Company, describing the layout of the plant, the work produced, and the methods employed; while Mr. Piperoux gave a talk on the Power Plant of the French Liner, La France, in which he described the engine room and gave many interesting figures concerning the capacities and consumption of its various units.

CORNELL UNIVERSITY

William Kent addressed the Sibley College Student Branch on February 17 on the General Manager. He mentioned the fact that few men have the capacity to advance to high executive positions, and said that the qualifications necessary are health, education, special knowledge, tact, energy, industry, personality, initiative, aggressiveness, and a degree of laziness.

KANSAS STATE AGRICULTURAL COLLEGE

The organization meeting of the Kansas State Agricultural College Student Branch was held on February 20, and the following officers were elected: A. A. Potter, Honorary Chairman; Victor Whiteside, president; J. D. Parsons, vice-president; J. I. Michaels, secretary; C. W. Wyland, treasurer. Prof. J. D. Hoffman gave an address on Fundamentals in Heating and Ventilating, in which he made clear the distinction between inanimate engineering, i.e., piling up dollars, and animate engineering, i.e., accumulating health. To show the poor ventilation of the average public meeting place some very interesting figures were given. The paper was discussed by Shelby Fall, Prof. L. E. Conrad, C. W. Lane, Prof. A. A. Potter, G. B. McNair, and P. L. Meyrick.

LELAND STANFORD JUNIOR UNIVERSITY

At a meeting of the Leland Stanford University Mechanical Engineering Society on February 10, a paper on the Sugar Industry in the Hawaiian Islands was read by J. A. Gibb, one of the members. This covered the author's experiences in the islands for the last two years. A general discussion followed.

On February 17, a joint meeting of the mechanical, electrical, geological, mining, and civil engineering societies was held, at which M. M. O'Shaughnessy, city engineer of San Francisco, spoke on the Water System of San Diego, covering the subject from the time of the Mission Fathers to the present.

A paper on Irrigation Pumping Machinery, by W. H. Warren, and another on the Automatic Telephone, by C. F. Williams, were read at the meeting of February 24, and were discussed by those present.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

On March 4, C. B. Sawyer of the Dodge Manufacturing Company gave a brief and interesting talk on various kinds of driving, and showed a comparison of these various kinds with rope driving, before the Student Branch of the Massachusetts Institute of Technology.

On March 11, B. K. Hough, the New England representative of the Richardson Scale Company, gave a talk on Automatic Weighing and the precision which might be expected from the use of this system as applied to grain and coal, and also water. He explained at length the advantages of the uses of the equal balance and the drip systems.

MISSOURI UNIVERSITY

At a meeting of the Missouri University Student Branch on February 16, the following officers were elected: F. A. Huleman, chairman; F. H. Frauens, corresponding secretary; L. L. Leach, secretary and treasurer. Professor Newton gave a talk on pig casting machines, discussing the various makes and their advantages and disadvantages.

On March 2, L. L. Leach gave a talk on the operation of mines in southwestern Missouri and the design and construction of the machinery used there.

OHIO STATE UNIVERSITY

The following officers were elected at a meeting of the student branch of Ohio State University on February 26: C. J. Lauer, chairman; C. R. Codner, vice-chairman; L. W. Ganschow, secretary; H. D. Winbigler, treasurer.

On March 5 a banquet was held at which Profs. W. T. Magruder, E. E. Sanborn, Horace Judd and F. W. Marquis, and A. I. Brown, and Robert Neilan responded to toasts, coöperation being the keynote of the evening's discussion.

PENNSYLVANIA STATE COLLEGE

A meeting of the Pennsylvania State Student Section was held on February 19, at which reports of the senior inspection trips to New York, Philadelphia and Harrisburg were presented. Professor Mease spoke of the benefits derived, and a detailed description of the various plants was given by H. L. Swift.

On March 13 a joint meeting of the branch and of the Motive Power Club was addressed by C. E. Barba and H. A. Hey. Mr. Barba emphasized the necessity of the coöperation of the drafting and manufacturing departments of an industry; and Mr. Hey of the new field opened to engineers by the recent demand for greater safety and increased efficiency. He stated further that the Society stood ready to help the student members whenever possible and urged all to take advantage of its help. A reception was held at the close of the meeting.

POLYTECHNIC INSTITUTE OF BROOKLYN

On March 7 the Student Branch of the Polytechnic Institute of Brooklyn listened to an interesting paper on Safety Valve Capacity by William R. Van Nortwick of Manning, Maxwell & Moore, Inc., in which he pointed out the need of having excellent safety valves, since the modern tendency in power plants was to run the boilers above rated capacity. He illustrated by lantern slides that many boiler explosions were due to poorly designed safety valves.

STEVENS INSTITUTE OF TECHNOLOGY

The Stevens Engineering Society held a meeting on January 13, at which Frederick W. Taylor gave a talk on the Principles of Scientific Management.

SYRACUSE UNIVERSITY

On February 24, J. E. Rood (1914) gave a talk on the History and Development of the Steam Engine, before the Student Branch of Syracuse University. He briefly described the early so-called engines and contrasted them with the types of today; comparing them, in conclusion, in respect to their ability to use the B.t.u.'s generated from 1 lb. of coal. Prof. W. E. Ninde followed with a talk on the Value of the Early History of the Steam Engine to the Engineering Student.

UNIVERSITY OF CINCINNATI

J. I. Lyle gave an address before the Student Branch of the University of Cincinnati on February 12 on Air Conditioning Machinery, in which he discussed the subjects of dust prevention and humidity, illustrating his remarks by lantern slides.

On February 20 the branch made an inspection trip to Dayton, Ohio, where a number of plants were visited, including the Home Telephone Exchange, the home of the Delco motor starter, the National Cash Register Company, and the Dayton Power and Light plant.

On March 10, George K. Elliott of the Lunkenheimer Company gave a talk on Steam Value as a Metallurgical Problem. He spoke of the present day requirements essential for a good value and how different metals were alloyed to obtain these properties. The lecture was illustrated with some fifty slides, the microscopic views showing metal structure being exceptionally good.

UNIVERSITY OF ILLINOIS

The following officers were elected at a meeting of the University of Illinois Student Branch on February 27: C. R. Velzy, president; J. A. Wilson, vice-president; E. F. Gehrig, secretary; J. L. Alden, treasurer.

UNIVERSITY OF IOWA

On February 25 at a meeting of the Student Branch of the University of Iowa, F. A. Wahlgreen gave a talk on Some Features of the Keokuk Dam, describing the transmission lines and the dam itself.

UNIVERSITY OF KANSAS

Prof. F. W. Blackmar, Dean of the Graduate School of the University of Kansas, gave a talk before the Student Branch on March 5 on Some Factors of the High Cost of Living.

UNIVERSITY OF MAINE

On February 25 the Student Branch of the University of Maine attended the automobile show, holding a meeting in the auditorium. Full lines of nearly all the standard machines were shown, and the demonstrators explained the new improvements to the members.

UNIVERSITY OF MINNESOTA

At a recent meeting of the Student Branch of the University of Minnesota the following officers were elected: J. A. Colvin, chairman; J. L. Hartney, vice-chairman and corresponding secretary; R. R. Boyles, secretary; A. W. Holmberg, treasurer. A review of Mr. Polakov's paper, presented at the Annual Meeting of the Society, was given by James A. Colvin.

UNIVERSITY OF WISCONSIN

At a meeting of the Student Branch of the University of Wisconsin on February 13, Prof. J. G. D. Mack gave an instructive talk on the life of John Ericsson.

On March 5, Prof. A. G. Christie gave a talk on the Measurement of the Flow of Air, which was a brief of the paper by W. C. Rowse, presented at the Annual Meeting of the Society.

WASHINGTON UNIVERSITY

A. W. Lomis of the Westinghouse Electric Company gave an illustrated talk on Steam Turbo-Generators before the Washington University Student Branch on February 14, in which he compared the relative merits of the reaction type with the impulse.

YALE UNIVERSITY

The Yale Student Branch held a meeting on February 17 at which Dr. D. S. Jacobus gave an illustrated talk on the Construction and Operation of Steam Boilers. He followed the development of the Babcock & Wilcox boiler from the early types up to the present stage, and also discussed oil-burning boilers, comparing their efficiencies with those of the coal-burning boilers. A. C. Staley, Prof. L. P. Breckenridge and others discussed the paper.

On January 21, H. L. Gantt made an address on Training Workmen in which he emphasized the fact that the greatest increase in the efficiency of mill workers was obtained by giving them individual instruction on how to perform their work. He illustrated the effect of the bonus system by charts.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The published list of "men available" is made up from members of the Society. Further information will be sent upon application.

POSITIONS AVAILABLE

301 Chief engineer, by concern employing 1000 men manufacturing threshing machinery, steam and gas tractors. Applicant must be good executive, progressive, with ability to handle men and must be thoroughly competent to take charge of design and drafting work. Give address with information as to past experience, age and salary expected.

302 Assistant manager, by foundry making a specialty of medium and light weight steel castings of high grade. Must be capable of taking complete charge of production in the absence of general manager.

304 Expert steel man, engineer, good executive, familiar with manufacture of steel. Must have wide acquaintance and ability to secure confidence of steel men. Headquarters at Pittsburgh, but considerable traveling in this country and abroad. Name confidential; apply by letter.

306 Draftsman, experience in designing small motors or generators for automobiles, for factory manufacturing small interchangeable parts for electrical apparatus. Location, Massachusetts. Only those having three or four years' experience need apply. Salary $18 to $22.

307 Production manager, old establishment in Connecticut, requires a man of great force in field of manufacturing management. Applicant must have dominate influence in deciding what articles to drop from the present line, what to continue manufacturing, the equipment necessary to manufacture them at profit, and what new lines to set up. Class of goods is light brass ware and in conjunction with this firm is a good sized gray iron foundry.

309 Technical graduate; at least three years' experience, with capital to take financial interest and actively engage in a well developed consulting business in New York City. Confidential; apply through the Society.

320 Manager for oil and gas burning furnace department. Must be 30 or 35 years of age, with some selling experience or adaptability in this direction. Preference given to man with technical training as a mechanical or chemical engineer.

337 Draftsman; experienced in and capable of developing the design of water tube boilers, including setting plans. Must be neat, accurate workman, and have thorough technical and practical experience along this line. Confidential; apply through the Society.

338 Technical expert in purchasing department of large works near New York, making high-grade light metal products, to assist in selecting, buying and inspecting the many varied materials used; should be good metallurgist, fair chemist and familiar with fuels. Name confidential; apply by letter. Applicants should give age, education, experience, reference and approximate salary expected.

339 Master mechanic or plant engineer, up in power plant engineering, general plant engineering, and able to reduce cost of repairs and manufacture of equipment. Also one who has had all-round experience in engineering problems pertaining to plant operation.

340 Experienced sales manager who can invest about $5000 in a company manufacturing fireproof heat insulating and building material. Salary to be agreed upon. Little traveling. Location, New Jersey.

341 Technical graduate to take financial interest and if desired engage actively in water tube boiler specialties business, with a graduate of 20 years' business experience, who controls the United States patents. An interview in New York is requested. Name confidential; apply through the Society.

MEN AVAILABLE

140 Member; trained as a mechanical engineer and machinist, with experience as superintendent; for eight years conducted office as designing and contracting engineer. Desires position as representative of high-grade concern, preferably in field of equipment for the handling of materials in Ohio, and adjacent states, if necessary.

141 Associate-Member; 27 years of age, technical graduate. Four years' experience with one of the largest manufacturers of steam turbines in the country. Experienced in design, construction testing, and field erection of steam turbines, condensers, and power plant equipment; thoroughly familiar with power plant work and would be able to handle position as superintendent of power plant. Desires position with reliable firm of consulting engineers. Is willing to take part interest in business with right party.

142 Junior, M.E.; familiar with modern shop and office practice; good organizer; experienced in boiler manufacturing and general plate work in engineering. Desires position as manager or assistant manager of manufacturing concern or a department.

143 Technical graduate, age 37, with continuous experience since graduation in engineering work, chiefly in design of power plant, mining and mill machinery. More than ten years in charge of work as chief draftsman and chief engineer.

144 Member; production engineer and manager; experienced designer, organizer and producer; familiar with best methods of management, quality and speed production for

machinery, metal goods and textiles. Operated under Taylor system and others. Present work completed about June 1, and applicant desires permanent connections with growing or large concern desiring to maintain with its own organization a permanent policy of efficiency and improvement.

145 Member; wide experience in machinery, metals, processes and their requirements; has filled efficiently every position from machinist to production engineer and knows the cost of production and the value of quality. Accustomed to placing rigid contracts at rock bottom prices and can distinguish between low price and low cost. Desires a position as purchasing agent and engineer for large establishment.

146 Member; long experience, best references; competent to organize all departments of manufacturing plants along modern lines. Desires a position as works manager.

147 Mechanical engineer, Stevens graduate, with over ten years' practical experience in factory management, desires to locate as assistant to general manager or as works manager. Vicinity of New York preferred.

148 Associate, married; mature age, manager and director; experienced in developing and perfecting organization accounting, costs and analysis, selling departments and in the operation of complicated business. Long experience with maritime affairs both in this country and in Great Britain. Desires a position of executive responsibility.

149 Member, technical graduate, 31 years of age; extensive training and experience in central power station work, designing, purchasing, superintending construction and operating departments; consulting engineering work on large properties; power production investigations; cost reduction; experienced in mill and reinforced concrete construction work; at present employed, but desires a change for advancement. Desires a position as works manager, mechanical superintendent or efficiency expert with company of consulting engineers or large manufacturing corporation.

150 Member; technical graduate, 39 years of age, with 15 years' experience in machine shops and general mill engineering, the latter in an executive capacity. Desires a position with a large concern in New England. Best references.

151 Member; technical graduate with advanced degree, specialty of efficiency engineering, 10 years' experience in heating and ventilating, power plant engineering and operation. Desires a position as engineer on operation and improvements, with company operating large power plants.

152 Associate-Member; Cornell graduate would be interested in a position as manager with a reliable concern, preferably a manufacturer of power plant apparatus. Personal interview requested.

153 General utility executive, technically educated as a mechanical engineer, who, under the titles of assistant vice-president and secretary, has served as a general utility man for well-known manufacturers of machinery; duties including sales, advertising, development of new ideas, pushing out work and general office management; seeks a responsible position where a wide engineering knowledge will be of value.

154 Associate-Member, Englishman, wishes to represent in London, England, an American concern. Wide experience in power plant machinery, its design, manufacture, operation and sales. Experience with several large concerns both in England and the United States; preferably a position with a small salary and commission. Intimate with the requirements of the British market in this line. Results guaranteed.

155 Junior; technical graduate, four years' experience in shop, drafting room, and office; at present employed as assistant to chief engineer with one of the large ball-bearing manufacturers. Desires a similar position with manufacturing concern along engineering lines. Salary $1500.

156 Junior member, technical graduate, fourteen years' practical experience, wishes position as superintendent or production manager.

157 Junior, age 29 years, graduate M.E.; eight years' experience in design and erection of steam power plants. Desires a position as constructing engineer or assistant to mechanical engineer with firm that can offer something of a permanent character. Salary $175-$200.

158 Junior industrial engineer, Junior member, college and technical graduate, five years' experience, desires position with concern contemplating installation of modern and systematic methods of manufacturing or starting the manufacture of a new product; can handle men and get results. At present and for the past three years employed as an industrial engineer by a large eastern manufacturing corporation; work nearing completion, therefore desires to establish new and permanent connection with manufacturers desiring executive of energy and ability.

159 Member; thirty years' experience in the largest engineering firms in England and America; nine years' experience as chief superintendent in steam turbine works, manufacturing all sizes from five to ten thousand horsepower. At present employed; desires permanent position as works manager or superintendent.

160 Junior, Stevens graduate, 30 years of age, varied experience in the office of a consulting engineer; complete charge of work and considerable responsibility. Has experience in reports, designs and appraisals of numerous industrial and power plants and municipal works. Best references.

161 Member; wide experience in designing, building and operating. At present in charge of large construction work nearing completion, also surface equipment of two mines and gravel plant on Pacific Coast. Has made special study of economical methods of handling materials. Accustomed to handling men, organizing crews, drawing up contracts, designing and purchasing. Is familiar with steel business. Desires connection with some large firm. Prefers to locate on the Pacific Coast.

162 Mechanical engineer, technical graduate, age 30, desires responsible position. Thorough knowledge of all types of pumps and pumping machinery, gasolene and oil engines, steam engines, and sugar house machinery. Drawing room, erection room and engineering department experience in large pump manufacturing company. Sugar plantation work in Mexico and sales engineer in Brazil. Natural ability in handling men and getting results. Best references.

163 Mechanical engineer, technical graduate, 25 years of age; several years' experience as factory inspector; familiar with all classes of manufacturing. Open for engineering work. Best references.

164 Member; wishes to get in touch with concern having ample machine shop facilities and organization for building and marketing new, fully protected, device for which there is a wide and profitable market.

165 Specialist in the practical manufacture of pumps, steam, gas, oil, gasolene and kerosene engines; sales work and power plant construction, and until recently vice-president of a million dollar corporation manufacturing all forms of pumps and prime movers. Desires connection with concern of some importance in capacity of engineer, or preferably, sales work.

166 Junior member, age 31, single, graduate in mechanical and electrical engineering departments of large technical

school, desires to make connection with firm where industry, capacity, and conscientiousness will be appreciated and rewarded. Applicant has ten years' experience in operating, designing and constructing substations, designing steel towers, selling small gas engines, city railway work. Can give best of references, and will start at a reasonable salary.

167 Member, 36 years of age; qualified to take charge of mechanical matters; experienced in designing, superintending construction and equipment of plants; some experience in purchasing and cost departments.

168 Junior member, age 27 years, graduate mechanical engineer, five years' experience in automobile manufacture and design, for the last two and one-half years in charge of experimental department in one of the leading automobile factories building a high priced car. At present employed.

169 Junior member; consulting mechanical engineer with office in Philadelphia wishes to arrange with a company in the vicinity able to use a portion of his time. Ten years' practical experience.

170 Member, technical graduate in mechanical and electrical engineering; six years' shop experience and four years as traveling salesman. Desires to represent a first class company in Philadelphia or vicinity as manufacturers' agent.

171 Managing sales engineer, open for contract to build up business with New York as headquarters. Has specialized in power plant equipment, contractors and conveying machinery. Practical shop and field experience; diplomatic and progressive.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary Am.Soc. M.E.

American Journal of Public Health. Air Supply and Ventilation Number, November 1913. *New York, 1913.*

American Railway Association. Proc. Regular Session, November 19, 1913. Gift of association.

The American Society of Mechanical Engineers. Year Book, 1914. *New York, 1914.*

Bautechnische Gesteinsuntersuchungen, J. Hirschwald. vol. 3, 1912, pt. 2. *Berlin, 1913.*

Carnegie Foundation for the Advancement of Teaching. bul. no. 7, pts. 1-2. *New York.* Gift of foundation.

Chemistry of Raw Water Can Ice, J. C. Sparks. *Milwaukee.* Gift of Vilter Manufacturing Co.

Enoch Pratt Free Library. 28th annual report of librarian to Board of Trustees, 1913. *Baltimore, 1914.* Gift of library.

Factory Organization and Administration, Hugo Diemer. ed. 2. *New York, 1914.*

The second edition has been rearranged and some new matter added. The fact that a new edition of 6000 copies is needed after four years is good evidence of the interest taken by factory managers in questions of administration.

Graphics and Structural Design, H. D. Hess. *New York, 1913.*

Heating and Ventilation. (cat. no. 215. B. F. Sturtevant Company.) *Hyde Park, 1914.* Gift of company.

International Association of Fire Engineers. Proc. 41st annual convention. *Roanoke, 1913.* Gift of association.

Isometric Drawing, A. P. Jamison. *New York, 1911.*

Machinery's Handbook for Machine Shop and Drafting Room. *New York, The Industrial Press, 1914.*

The editorial staff of Machinery have been collecting material for this work and publishing it from time to time in their periodical. This has been segregated, much new matter added, and the whole is now printed in this volume of 1400 pages of handy size. This forms an encyclopedia of engineering data which should be of the greatest service to designers and draftsmen.

Manual of Shoemaking and Leather and Rubber Products, Wm. H. Dooley. *Boston, 1912.*

Mechanical Engineer's Reference Book, H. H. Suplee. ed. 4. *London-Philadelphia, 1913.*

Mechanical Laboratory Methods. The testing instruments and machines in the mechanical engineering laboratory and in practice, Julian C. Smallwood. *New York, D. Van Nostrand Co., 1914.*

The design of Professor Smallwood's work is to furnish a brief manual for students, eliminating material which is readily accessible in other books, or with which the students should be already familiar. Several new testing methods are included, as well as some original formulae.

Millers' Almanack and Trade Year-Book, 1913-14. *Minneapolis, 1913.* Gift of Northwestern Miller.

National Gas Engine Association. Proc. sixth annual convention. *Lakemont, 1913.* Gift of association.

Isaaci Newtoni Opera que Exstant Omnia. 5 vols. Commentariis Illustrabat Samuel Horsley. *London, 1779, 1882, 1885.*

Observations on the Elevated and Sub-railways of London, applied to a Metropolitan Sub-railroad for the City of New York, O. Vandenburgh. *New York, 1864.*

Official Congressional Directory. ed. 2, 1914. (63d Congress, 2d Session.) *Washington, 1914.* Gift of U. S. Congress.

Past, Present and Future of Railway Clubs, D. M. Brady. *New York, 1913.* Gift of author.

Recall of Constitutional Safeguards, R. G. Brown. Annual address before the Oklahoma State Bar Association, December 29, 1913. *1913.* Gift of author.

San Francisco Association of Members of the American Society of Civil Engineers. Constitution and List of Members, 1914. *San Francisco.* Gift of association.

Stätten deutschen Lebens und deutscher Arbeit. (To the members of the Society in remembrance of their visit to Germany, 1913.) Gift of H. H. Weber.

Telephone Society of New York. Annual 1913-1914. Gift of society.

A Tube to Ireland, H. G. Tyrrell. Gift of author.

U. S. Commissioner of Navigation. Annual report to the Secretary of Commerce, 1913. *Washington, 1914.* Gift of commissioner.

Die Walzwerke Einrichtung und Betrieb, A. Holverscheid. *Leipzig, 1912.*

Work, Wages and Profits, H. L. Gantt. ed. 2. *New York, Engineering Magazine Co., 1913.* Gift of Publishers.

This book was incorrectly entered in the March 1914 issue of The Journal, as the gift of Mr. F. M. Griswold. The first edition published in 1910, was a small volume of less than two hundred pages. This second edition has over three hundred pages with much new matter, embodying results in machine shops, metal-working and locomotive building plants. W. P. C.

Gift of The American Society of Mechanical Engineers

Adler Automobiles, Price List, 1913.

Bayer & Co. The development of the Farbenfabriken vorm, 1912.

Bericht über die unter dem Vorsitze Sr. Königl. Hoheit des Prinzen Ludwig von Bayern am 28 Juni 1903.

Breuer & Co., Locomotiv Wasserkrane. cat. no. 5, 1912.

Darstellungen aus der Geschichte der Technik der Industrie und Landwirtschaft in Bayern, 1906.

Der Industrie Hafen. *Demag-Duisburg.*

Deutsche Industrie Deutsche Kultur, no. 7, Jahrgang 6.

Stahlwerke Rich. Lindenberg, Aktiengesellschaft Remscheid-Hasten.

DEUTSCHES MUSEUM: Descriptive pamphlet. (German.)
——— Führer durch die Sammlungen.
——— Satzung.
——— Vorträge und Berichte. pts. 1-11.
——— Verwaltungs Bericht. 3-5, 7-9, 1906-1912.
——— A walk through the collections.

DEUTSCHER NATURFORSCHER UND AERZTE. Festchrift der LXXI Versammlung Die entwicklung Münchens unter dem einflüsse der Naturwissenschaften.

DEUTSCHEN VEREINS VON GAS UND WASSERFACHMANNERN, *München, 1912.* Festschrift zur 53 Jahresversammlung. Die Versorgung der Königlichen Haupt u. Residenzstadt München mit Gas und Wasser.

DIE DURCHGEISTIGUNG DER DEUTSCHEN ARBEIT. (Jahrbuch des Deutschen Werkbundes 1912.) *Jena, 1912.*

FRANKFURT-ON-MAIN. New East Harbour (descriptive catalogue).
——— Das eiserne Jahrhundert, 1813-1913.
——— Guide to some of the public works. *1907.*
——— Ein Führer durch seine bauten, 1886-1910.

GASMOTOREN FABRIK DEUTZ. Erstes und ältestes Werk für den Bau von Verbrennungsmotoren.

GÜTEHOFFNUNGSHÜTTE, AKTIENVEREIN FUR BERGBAU UND HÜTTENBETRIEB, Oberhausen (Rheinland).

HISTORISCH-BIOGRAPHISCHE BLÄTTER. Industrie, Handel und Gewerbe. (*a*) Der Regierungsbezirk Cassel, (*b*) Der Regierungsbezirk Wiesbaden.

HUMBOLDT—MASCHINENBAU-ANSTALT (Gesamt-Katalog).

HUMBOLDT ENGINEERING WORKS. cat., 1910-1912.

JAEGER & CO. Pumpen und Gebläse Werk.

KAHN, J. Grossindustrie und Grosshandel. *1891.*

KÖLNER BEZIRKS-VEREIN DEUTSCHER INGENIEURE GESCHICHTLICHE AUFZEICHNUNGEN 50 JAHRE.

KÖNIGLICH SÄCHISCHEN TECHNISCHEN HOCHSCHULE ZU DRESDEN. Die Neubauten. *1905.*

KRAUSE, KARL. cat., 1913.
——— Machines for the whole paper industry.

KRUPP, FRIED. Führer durch die Friedrich-Alfred Hütte.
——— Zur Hundertjahrfeier der Firma, 1812-1912.

LANZ, HEINRICH. Fünfzig jahre des wirkens in Landwirtschaft und Industrie, 1859-1909. 2 vols.

MÜNCHEN UND SEINE BAUTEN. *1912.*
——— Pläne.

OPEL, ADAM UND SEIN HAUS. Fünfzig jahre der entwicklung, 1862-1912.

PFAFF, KARL. Heidelberg und Umgebung. ed. 3, 1910.

POKORNY & WITTEKIND MACHINE WORKS, LTD. Air Compressors (English and German). 2 vols.

RHEINISCHE STAHLWERKE LTS. Duisburg-Meiderich. cat., 1910.

RUFF, F. Reference Book for Statistical Calculations (English and German). 2 vols. *London-Paris, 1905.*

SACK, RUD. cat. of works, 1863-1913.

SCHIESS-ERNST. Catalogue of Machine Tools for Heavy Work, 1912.

SEIDEL UND NEUMANN. 40 Jahre Fabrikationsgeschichte, 1868-1908.

SIMON, BÜHLER & BAUMANN MÜHLENBAUANSTALT & MASCHINENFABRIK. Abteilung: Mühlenbau.
——— Brauerei Mälzerei-Einrichtungen.
——— Special Katalog für Entstaubungs Lüftungs und Heizungs Anlagen. Katalog A,B,D, und Haupt Katalog.

STAHLWERKE RICH. LINDENBERG AKTIENGESELLSCHAFT. Elektro-Glocken-Stahl. (Liste no. 5.)

SULZER BROS. cat. on Steam Engines. (German and English.) 2 vols.

THYSSEN & CO. cat.

VEREINES DEUTSCHER INGENIEURE. Ingenieurwerke an und bei Berlin. *1906.*

DER VEREIN DEUTSCHER INGENEIURE UND SEINE ARBEITEN. *1910.*

VOIGT & HAEFFNER, A. G. Die Neuen werke.

VON DYCK, WALTHER GEORG VON REICHENBACH. *1912.*
——— Uber die errichtung eines Museums von Meisterwerken der Naturwissenschaft und Tecknik in München. *1905.*

DIE WASSERVERSORGUNG DER KÖNIGL. Haupt und Residenzftadt München ihre entwicklung und ihr gegenwärtiger Stand. *1912.*

UNITED ENGINEERING SOCIETY

AMERICAN NEWSPAPER ANNUAL AND DIRECTORY, 1914. *Philadelphia, 1914.*

CARNEGIE ENDOWMENT FOR INTERNATIONAL PEACE. Some roads towards peace. A report to the trustees of the endowment on observations made in China and Japan in 1912, Chas. W. Eliot. *Washington, 1914.* Gift of Carnegie Endowment.

EAGLE ALMANAC, 1914. *New York, 1914.*

INTERNATIONAL ACETYLENE ASSOCIATION. Proc. 16th annual convention, 1913. *New York, 1913.* Gift of association.

PATENTS, TRADE-MARKS, DESIGN PATENTS, H. C. Thomson. *Boston, 1913.*

POCKET GLOSSARY OF ENGLISH-GERMAN, GERMAN-ENGLISH TECHNICAL TERMS FOR ENGINEER AND MANUFACTURERS, J. G. Horner. *London, 1913.*

REGULATIONS FOR THE TRANSPORTATION OF EXPLOSIVES AND OTHER DANGEROUS ARTICLES BY FREIGHT AND BY EXPRESS AND SPECIFICATIONS FOR SHIPPING CONTAINERS. Interstate Commerce Commission. *Washington, 1911.* Gift of Interstate Commerce Commission.

SPECIFICATIONS FOR TYPES OF ROADS AND PAVEMENTS AND MATERIALS OF CONSTRUCTION USED THEREIN TO BE USED BY THE NEW YORK STATE HIGHWAY DEPARTMENT RECOMMENDED BY A. H. BLANCHARD AND P. HUBBARD TO NEW YORK STATE DEPARTMENT OF EFFICIENCY AND ECONOMY, December 4, 1913. *Albany, 1913.* Gift of Messrs. Blanchard and Hubbard.

EXCHANGES

INSTITUTION OF CIVIL ENGINEERS. Minutes of Proc., vol. 193. *London, 1914.*

LIVERPOOL ENGINEERING SOCIETY. Trans., vol. 34. *Liverpool, 1913.*

THE LOCOMOTIVE. vol. 29. *Hartford, 1912-1913.*

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS. Trans., vol. 29. *Newcastle-upon-Tyne, 1913.*

STEVENS INSTITUTE OF TECHNOLOGY. cat., 1914-1915. *Castle Point, N. J., 1914.*

TRADE CATALOGUES

CURTIS PNEUMATIC MACHINERY CO., *St. Louis, Mo.* Cat. no. 62, air compressors, air hoists, air cranes, etc.

GARDNER MACHINE CO., *Beloit, Wis.* Gardner grinder, January and February 1914.

MORRIS, D. P., CO., *Philadelphia, Pa.* bul. no. 3, hydraulic turbines.

NEUMEYER AND DIMOND, *New York.* Founders and managers of our works, past and present, 92 pp.

NORTHERN ENGINEERING WORKS, *Detroit, Mich.* Cat. no. 26, northern cranes.

PERFECTION SPRING CO., *Cleveland, O.* Your new car, 1914.

SIMPLEX WIRE AND CABLE CO., *Boston, Mass.* Simplex manual, 1914.

TERRY STEAM TURBINE CO., *Hartford, Conn.* bul. no. 6, Terry vertical steam turbine blower unit, March 1910; bul. no. 7, gas blowers, October 1910; bul. no. 11, cupola blowers, June 1911; bul. no. 12, gas blower data, Sep-

tember 1911; bul. no. 14, generating sets, September 1911; bul. no. 15, test of a high pressure blower set, October 1911; bul. no. 16, marine service, June 1912; bul. no. 17, return flow turbine, October 1913. Cat. 13, Terry turbine, 100-h.p. as installed in new stations of the Boston Elevated Railway and Minneapolis General Electric Company, October 1911. Terry Service, 11 pp. Terry turbines, 12 pp.

UNDER-FEED STOKER CO. OF AMERICA, *Chicago, Ill.* Publicity magazine, January 1914.

PUMPING WATER BY COMPRESSED AIR

LIST OF REFERENCES COMPILED BY HELEN M. CRAIG, REFERENCE LIBRARIAN, ENGINEERING SOCIETIES LIBRARY.

AN INVESTIGATION OF THE AIR LIFT PUMP, Geo. J. Davis and Carl Robt. Weidner. University of Wisconsin, *Bulletin, Engineering Ser.*, vol. 6, no. 7, 1911, 167 pp. il. Madison, Wis., Price, 40 cents. Gives data obtained from experiments, also a brief history of the use of compressed air for pumping. Pages 161-167 contains a bibliography, dating from 1885.

THE AIR LIFT SYSTEM, F. W. Schmidt. *Yale Scientific Monthly*, January 1913, pp. 273-278.

RAISING WATER BY COMPRESSED AIR, Frank Richards. *Power*, vol. 35, pp. 684-685, 1912.

COMPRESSED AIR FOR RAISING WATER, Frank Richards. *Compressed Air*, July 1912, pp. 6484-6487.

PUMPING BY COMPRESSED AIR, Herbert T. Abrams. *School of Mines Quarterly*, vol. 33, pp. 293-311, 1912. Abstract in *Canadian Engineer*, vol. 22, pp. 779-784, 1912. Discussion of the four methods of using compressed air for raising water.

EXPERIMENTS WITH AIR LIFTS. *Engineering Record*, vol. 57, pp. 745-746, 1908. Tests made on a driven well 174 ft. deep to determine the amount of water raised, air required, etc.

COMPRESSED AIR PUMPING PLANT, MERIDIAN, IDAHO, Le Roy W. Allison. *Power*, December 16, 1913, pp. 842-843.

TEST OF AN AIR LIFT PUMPING PLANT AT ATLANTIC CITY, AND EXPERIMENTAL STUDIES OF AIR LIFT PUMPS. *Engineering News*, vol. 59, p. 666, 1908. The wells averaged 101 ft. in depth.

PUMPING WELLS BY COMPRESSED AIR FOR WATER SUPPLY AT PALMERSTON, ONTARIO, O. W. Smith. *Canadian Engineer*, vol. 16, pp. 481-484, 1909.

ARTESIAN WELL PUMPING BY COMPRESSED AIR, H. Tipper. *Engineering News*, vol. 59, p. 66, 1908.

RAISING WATER WITH COMPRESSED AIR, Philip R. Björling. *Municipal Journal*, vol. 15, pp. 245-249, 1903. Abstract from the *Engineering Times*, London.

AIR LIFT PUMPING PLANT OF THE REDLANDS WATER CO. *Engineering Record*, vol. 51, p. 8, 1905.

A TEST OF THE POHLE AIR LIFT PUMP AT DEKALB, ILL., L. B. Merriam. *Engineering News*, vol. 32, p. 27, 1894.

DEEP WELL PUMPING, E. E. Johnson. *Western Society of Engineers, Journal*, vol. 2, pp. 169-189; discussion, pp. 190-229, 1897. Describes the application of compressed air as used by the Pohle air lift.

ON THE RAISING OF WATER BY COMPRESSED AIR, AT PREESALL, LANCASHIRE, James Kelly. *Institution of Civil Engineers*, vol. 163, pp. 353-378, 1905-1906.

RAISING WATER BY THE AIR LIFT. *Engineering Record*, vol. 31, p. 363, vol. 32, p. 26, 1895. Description of plant at Rockford, Ill. The wells are 387 ft. deep.

PUMPING BY COMPRESSED AIR, Edward A. Rix. *Association of Engineering Societies*, vol. 25, pp. 173-216, 1900. Description of various kinds of pumps.

DEEP WELL PUMPING MACHINERY, D. W. Mead. *American Water Works Association, Proc.*, vol. 18, pp. 146-152; discussion, pp. 152-153, 1898.

SUPPLYING WATER FROM DEEP WELLS BY COMPRESSED AIR, C. W. Wiles. *American Water Works Association, Proc.*, vol. 20, pp. 22-24; discussion pp. 24-29, 1900.

A DIESEL ENGINE-DRIVEN AIR-LIFT PUMPING PLANT. *Engineer* (London), March 13, 1914, p. 287-288.

DESCRIPTION OF AND TEST DATA ON THE HIGH DUTY AIR LIFT WATER PLANT AT PLAINFIELD, N. J. *Engineering and Contracting*, December 24, 1913, p. 709-711.

BOOKS

GREENE, ARTHUR M. Pumping Machinery, a treatise on the history, design, construction and operation of various forms of pumps. *New York, Wiley, 1911.*
Chapter 13—Air-lift Pumps and Pneumatic Pumps.

HARRIS, ELMO G. Compressed Air, Theory and Computations. *New York, McGraw-Hill Book Co., 1910.*
Chapter 6—The Air-lift Pump.

HISCOX, GARDNER D. Compressed Air, its production, uses and applications. *New York, Henley Co., 1901.*
Chapter 32—Compressed air work. Compressed air for raising water.
Chapter 36—Patents issued by the United States Patent Office on compressed air and its appliances, from 1875 to July 1, 1901.

PEELE, ROBERT. Compressed Air Plant. Ed. 2. *New York, Wiley, 1910.*
Chapter 25—Pumping by the direct action of compressed air.

RICHARDS, FRANK. Compressed Air Practice. *New York, McGraw-Hill Book Co., 1913.*
Chapter 24—The Air-lift.

ROGERS, WILLIAM. Pumps and Hydraulics. Part 2. *New York, Audel, copyright, 1905.*
pp. 79-90—The Air-lift Pump.

SAUNDERS, W. L., editor. Compressed Air Information; or, a Cyclopedia containing practical papers on the production, transmission and use of compressed air. *New York, "Compressed Air," copyright, 1903.*

GIBSON, A. H. Hydaulics and its Application. *New York, Van Nostrand, 1908*, pp. 668-674. The air lift pump.

PEELE, ROBERT. Compressed Air Plant. Ed. 2. *New York, Wiley, 1910.*

GREENE, ARTHUR M. Pumping Machinery. History, design, construction and operation of various forms of pumps. *New York, Wiley, 1911.* Chapter 13—Air lift pumps and pneumatic pumps.

HIGH PRESSURE FIRE SERVICE

BALTIMORE HIGH PRESSURE FIRE SERVICE, James B. Scott. *American Society of Mechanical Engineers, Journal*, March 1913, pp. 373-419.

THE HIGH PRESSURE FIRE SERVICE, John E. Codman. *Engineers' Club of Philadelphia, Proceedings*, October 1913, pp. 325-37; discussion pp. 337-40.

THE DESIGN, CONSTRUCTION AND OPERATION OF THE BALTIMORE HIGH PRESSURE FIRE SERVICE SYSTEM. *Engineering and Contracting*, vol. 39, pp. 436-43, 1913. Gives construction costs and results of tests.

HIGH PRESSURE FIRE MAINS IN PHILADELPHIA, John E. Codman. *Engineering Record*, vol. 66, p. 523, 1912.

MANAGEMENT OF HIGH PRESSURE FIRE SYSTEMS. *Engineering Record*, vol. 65, pp. 580-81, 1912. Committee Report of National Fire Protection Association.

HIGH PRESSURE FIRE SERVICE SYSTEM IN BALTIMORE, MD. *Engineering News*, vol. 68, pp. 210-11, 1912. Gives results of tests made by the National Board of Fire Underwriters.

BALTIMORE HIGH SERVICE FIRE SYSTEM. *Insurance Engineering*, August 1912, pp. 72-83. Quotes from report of National Board of Fire Underwriters.

San Francisco High Pressure Fire System, W. H. Ticknor. *Insurance Engineering,* September 1912, pp. 129-140.

Baltimore High Pressure Fire Service. *Municipal Journal,* vol. 33, pp. 107-110, 1912.

High Pressure Fire Service Compared with Portable Fire Engines, Chas. A. Hague. *American Water Works Association, Proceedings,* 1911, pp. 369-91.

High Pressure Water Service for Fire Protection, J. B. Sando. *Western Society of Engineers, Journal,* vol. 16, pp. 117-138; discussion pp. 138-142, 1911. Describes systems used in various cities.

High Pressure Service in New York City, Edward F. Croker. *Fire and Water Engineering,* vol. 48, pp. 145-6, 1910. Paper read at convention of International Association of Fire Engineers.

High Pressure Fire Service: Its Operation and Efficiency, J. E. Buchanan. *Fire and Water Engineering,* vol. 48, pp. 147-8, 1910. Paper read at convention of International Association of Fire Engineers.

High Pressure Fire Protection System at Oakland, Cal. *Engineering Record,* vol. 62, pp. 97-99, 1910.

High Pressure Fire Service Pumps of Manhattan Borough, City of New York, R. C. Carpenter. *American Society of Mechanical Engineers,* vol. 31, pp. 437-62; discussion pp. 462-510, 1909.

Winnipeg's High Pressure Service, H. V. Ross. *Municipal Journal and Engineer,* April 28, 1909, pp. 707-09.

Fire Protection at San Francisco. *Municipal Journal and Engineer,* June 16, 1909, pp. 1099-1102.

Toronto High Pressure Fire System, C. L. Fellowes. *American Water Works Association, Proceedings,* 1909, pp. 700-10.

The Brooklyn High Pressure Water System for Fire Protection. *Engineering Record,* vol. 57, p. 702, 1908.

City of Winnipeg, High Pressure Fire Service. *Canadian Engineer,* vol. 15, pp. 407-08, 1908.

New York's Electrically Operated High Pressure Water System for Fire Protection. *Electrical World,* vol. 51, pp. 555-58, 1908.

Proposed Auxiliary High Pressure Fire Protection Water Supply at Hartford, Conn. *Engineering News,* vol. 58, p. 53, 1907. With table showing fire protection in 21 cities.

High Pressure Water Systems, F. L. Hand. *American Water Works Association, Proceedings,* 1906, pp. 411-52. Gives costs of Philadelphia system.

Philadelphia Gas Engine Pumping Station for Fire Service. *Engineering Record,* vol. 49, pp. 309-13, 1904.

3,000 Horsepower Gas Engine Pumping Station for High Pressure Service, J. R. Bibbins. *Engineer* (Chicago), vol. 41, pp. 206, 239, 272, 1904.

Gas Power for High Pressure City Fire Service, J. R. Bibbins. *Cassier's Magazine,* vol. 25, pp. 387-406, 1904.

Fire Mains, John C. Trautwine, Jr. *Engineers' Club of Philadelphia, Proceedings,* vol. 20, pp. 42-78; discussion pp. 79-82, 1903. Reviews systems installed in various cities.

Philadelphia High Pressure Fire Service, John E. Codman. *Engineers' Club of Philadelphia, Proceedings,* vol. 20, pp. 83-98; discussion pp. 99-101, 1903.

A New 2,300 H.P. Gas Engine Installation for High Pressure Fire Service in Philadelphia. *Engineering News,* vol. 48, pp. 144-45, 1902.

Description of the Separate High Pressure Fire Service System at Providence, R. I., Edmund B. Weston. *New England Water Works Association,* vol. 13, pp. 85-91; discussion pp. 91-3, 1898.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ABRIDGED LIST OF OFFICERS AND COMMITTEE CHAIRMEN[1]

James Hartness, *President* Calvin W. Rice, *Secretary*

R. M. Dixon, Finance Committee
H. R. Cobleigh, House Committee
Leonard Waldo, Library Committee
L. P. Alford, Committee on Meetings
Hosea Webster, Committee on Membership
C. I. Earll, Publication Committee
Fred J. Miller, Public Relations Committee
R. H. Rice, Research Committee
Jesse M. Smith, Committee on Constitution and By-Laws

LOCAL MEETINGS

Atlanta: J. S. Coone
Boston: R. E. Curtis
Buffalo: W. H. Carrier
Chicago: Paul P. Bird
Cincinnati: A. L. DeLeeuw
Milwaukee: E. P. Worden
Minnesota: Max Toltz
New Haven: E. S. Cooley
New York: R. V. Wright
Philadelphia: D. R. Yarnall
San Francisco: Robert Sibley
St. Louis: F. E. Bausch

[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1914, and in the January and July 1914 issues of The Journal.

PERSONAL NOTES

Fifty-three lantern slides with descriptive notes on the Engineering Societies Building, the home of the Society, are at the disposal of the local sections and student branches of the Society, and may be secured upon request from the Secretary.

Elliott H. Whitlock, Manager of the Society, who has been connected with the carbon industry and the management of plants in other lines for nearly eighteen years, has recently opened his own office in Cleveland as consulting engineer and carbon expert. Mr. Whitlock is naturally familiar with all the details of carbon manufacture and its economical production. He will specialize also in efficiency management, installing new methods in manufacturing concerns which are not now on a paying basis, so that they may continue on a sound basis.

Theodore T. Mersereau has been appointed inspector of steam and motor vessels for the inland waters of the State of New York, under the Department of Public Works, with headquarters at Albany. He has been for the past five years Atlantic Coast representative for the Kingsford Foundry & Machine Works of Oswego, N. Y., in the marine boiler department. Mr. Mersereau still retains his membership on the advisory committee for marine engineering of the West Side Y. M. C. A. school of marine engineering, now in its tenth year.

At the annual meeting of the Polytechnic Institute of Brooklyn Student Branch on April 25, Calvin W. Rice, Secretary of the Society, delivered an address.

Julian Richmond, assistant engineer of the Board of Water Supply of New York, has been commissioned to establish the city exhibit at the International Urban Exhibition to be held at Lyons, France, between May 1 and November 1, and will sail for France within a few weeks.

Stewart M. Marshall, formerly chief engineer of the Cambria Steel Company, Johnstown, Pa., has accepted the position of assistant general manager of A. J. Haws & Sons, Ltd., of the same city.

The New York office of the Mumford Molding Machine Company was closed April 1, and E. H. Mumford, vice-president and general manager, has moved his office to the factory in Chicago, Ill., in order that he may be in close touch with the business.

Chester W. Wilson, until recently associated with the Saco-Lowell Shops, Lowell, Mass., has accepted the position of assistant superintendent of the Dolphin Jute Mills, Paterson, N. J.

C. J. Kryzanowsky has become connected with The Crown Cork & Seal Company, Baltimore, Md. He was formerly in the employ of the General Motors Company, Detroit, Mich.

Bernard M. Fine, who was until recently draftsman of the Standard Roller Bearing Company, Philadelphia, Pa., has accepted a position with the Dunlap Wire Wheel Corporation of America, Richmond Hills, L. I., N. Y.

Norman B. Roper has become general superintendent of reduction works of the Backus & Johnston Company, Casapalca, Peru, S. A.

William F. Austin, until recently superintendent of the Eddystone, Pa., plant of the Belmont Iron Works, has accepted the position of superintendent of the New England Structural Company, Everett, Mass.

C. Howard Bartlett is now vice-president of Chas. A. G. Winther Company, Inc., Boston, Mass. He was formerly construction engineer with the Stone & Webster Engrg. Corporation of the same city.

John E. Fulweiler has accepted a position with the American Gas Utilities Co., Atlanta, Ga., as engineer. He was until recently associated with Perkins, Fulweiler & Company of Philadelphia, Pa.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

At a meeting on April 1 of the Armour Institute of Technology Student Branch, W. A. Blonck read a paper on Modern Boiler Room Operation, which was illustrated by lantern slides.

CARNEGIE INSTITUTE OF TECHNOLOGY

The Carnegie Institute of Technology Student Branch held a meeting on March 16, at which Geo. S. Cooper, Mem. Am. Soc. M. E., spoke on the Buckeye Locomobile. Mr. Cooper traced the history and development of the locomobile from its origin in Germany to its present state; he then continued with the advantages to be gained from the adoption of the unit power plant, giving results that have been obtained from this kind of motive power under test, which showed the steam and coal consumption to be exceedingly small. The paper was illustrated by lantern slides and a general discussion followed.

COLUMBIA UNIVERSITY

Target Practice was the subject of the talk given by Lieut. B. R. Ware, U.S.N., before the Mechanical Engineering Society of Columbia University on March 18. Lieutenant Ware first pointed out the importance of target practice, citing how superior marksmanship in the Spanish-American and Russo-Japanese wars played the leading part in the victories. He then explained to the audience the method of range finding, the extensive systems of communication within the ship, and the control and firing of the big guns. As an illustration of the damage wrought by the huge shells, and the accuracy of the gunners, Lieutenant Ware told of the target practice on the old Texas, where conditions were made as nearly as possible like actual battle conditions. A general discussion followed the address.

KANSAS STATE AGRICULTURAL COLLEGE

The first regular meeting of the Kansas State Agricultural College Student Branch was held March 5. Prof. Roy A. Seaton, Junior, American Society of Mechanical Engineers, gave an extemporaneous talk on Centrifugal Air Compressors, discussing the development of the compressor, its application and desirability of use. W. W. Haggard gave a review on the operation of large boilers, pointing out the method of testing for efficiency and system of management. W. A. Buch reviewed the papers published in the January and February issues of The Journal, with special reference to the more theoretical articles.

LEHIGH UNIVERSITY

Geo. P. Nachman gave a brief talk on Improved Gear Cutting Methods, at a meeting of the Lehigh University Student Branch on March 24. His talk summarized the means used to form spur gears, and touched on the Fellows gear shaper. Calvin W. Rice, Secretary of the Society, followed with a short address on the Greater Appreciation of the Engineer. A social evening followed.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

On March 25 Henry K. Rowell, Member American Society of Mechanical Engineers, gave a detailed discussion of his experiences in the layout of cotton mills, and illustrated his talk with lantern slides.

On April 1 Ralph E. Curtis, Member American Society of Mechanical Engineers, gave a unique talk on the Purchasing of Supplies. He dwelt at length upon the importance of an intelligent description of what was wanted; touched on the financial and organization element, and concluded with an appeal for coöperation between the engineer and the purchasing agent.

OHIO STATE UNIVERSITY

On March 25 the Ohio State University Student Branch were the guests of the electrical engineering student branch of the same university. The address was delivered by R. E. Rohrer and J. J. Linebaugh of the General Electric Company on The Electrification of the Butte, Anaconda and Pacific Railroad Company.

On April 1 Prof. Wm. T. Magruder, Member American Society of Mechanical Engineers, lectured on the Engineering Societies Building in New York, and illustrated his talk with lantern slides. A number of students from the mining and electrical engineering student branches were present.

POLYTECHNIC INSTITUTE OF BROOKLYN

On April 4 Carl F. Dietz, Member American Society of Mechanical Engineers, spoke before the Polytechnic Institute Student Branch on the subject of Grinding. Mr. Dietz brought samples of grinding from the Norton Grinding Company, as well as numerous lantern slides, all of which demonstrated that grinding has had a marked influence on machine shop practice, and that its consideration in the engineering world demands careful study by the engineer.

RENSSELAER POLYTECHNIC INSTITUTE

At a meeting of the Rensselaer Polytechnic Institute Student Branch on March 26, A. Padron described the Uniflow Engine, including a graphical method for determining the best compression for a given cut-off. Prof. A. M. Greene, Jr., Member American Society of Mechanical Engineers, followed with an illustrated lecture on the Engineering Societies Building in New York, which was illustrated by lantern slides.

On April 13 C. Finch presented a paper on the Design of a 700-H.P., Double-Runner, Horizontal Hydraulic Turbine, and W. Schutz on the Design of a 400-H.P., Three-Cylinder Diesel Engine for Marine Service.

STEVENS INSTITUTE OF TECHNOLOGY

On February 24 Stevens Engineering Society was addressed by Edwin B. Katte, Member American Society of Mechanical Engineers, on the Electrification of the Grand Central Terminal. The lecture was illustrated by lantern slides giving in detail the development of the electrical equipment of the New York Central Railroad, showing the new and the old type of electrical locomotives, methods of distributing power, and detail descriptions of the power houses.

On March 13 Arthur E. Kennelly, professor of electrical engineering at Harvard University, delivered a lecture on Submarine Cable Telegraphy. The manufacture, operation and repair of cables were fully described by one who enjoys an enviable reputation as an authority on the subject.

Henry Hess, Member American Society of Mechanical Engineers, was the speaker at the meeting of March 24, and chose as his topics: Engineering Manufacture and Profit and Loss; and Color Photography.

UNIVERSITY OF CALIFORNIA

The following papers were read at the meeting of the University of California Student Branch held March 24: Methods and Means of Water Purification, G. A. Bush; The Depreciation Factor in Business Ventures, G. H. Briggs.

UNIVERSITY OF CINCINNATI

The University of Cincinnati Student Section was addressed on April 14 by Kenneth C. Grant, Member American Society of Mechanical Engineers. Mr. Grant's subject was Flood Prevention in the Great Miami Valley. He cited the natural and artificial causes of floods and enumerated three general prevention methods. The work that has been done by the Dayton Flood Prevention Committee was outlined and the results given of the engineering studies made under the direction of this committee. The studies showed that the cost of channel improvements would be prohibitive and that such improvements would seriously increase flood damages in the communities located in the lower valley, but that the entire valley could be protected by a system of seven "dry" reservoirs at a cost of about $17,000,000. The Conservancy Act of Ohio, necessitated by the lack of legal machinery for the coöperation of the various interests that would be benefited by the wide-spread flood protection afforded by the reservoirs, was explained in detail. Mr. Grant illustrated his talk with numerous lantern slides showing views of the Miami Valley during the flood of March 1913, and of some of the largest flood prevention reservoirs of Europe. In connection with the latter, it was stated that concrete had found little application in Europe for reservoir construction, broken stone being favored.

UNIVERSITY OF ILLINOIS

A meeting of the University of Illinois Student Branch was held on April 10, and Prof. O. A. Leutwiler, Member American Society of Mechanical Engineers, was the speaker of the evening. His topic was the Voting Machine, a subject on which he is well versed, as he was one of the committee appointed by the Governor to investigate the voting machines prior to their installation in Chicago.

UNIVERSITY OF KANSAS

At a meeting on April 2 of the University of Kansas Student Branch the following topics were discussed. Present Trend in Mechanical Features of Automobiles, C. L. Coggrins; and Up-to-Date Methods of Freight Handling on Large Railway and Steamship Terminal, D. B. Kliehege.

On April 16 W. L. Burdick presented a paper on Patent Laws, in which he gave a history of patent laws in this country and Europe. He defined patent as the exclusive right to manufacture, sell or use an article. A patentable article must be new and novel, and must be useful. Any new and useful art, machine, manufacture, composition of matter or design is provided for by law. If a description of the article has been published, or has been offered for sale for two years or more, it cannot be patented. Anyone can take out a patent, but the inventor or designer himself must make the application. The petition must contain a description of the article, followed by the claim of the originator, and accompanied by a fee of $15. Final papers, if secured, cost an additional $20. If two parties petition for a patent for the same thing at about the same time, this state of affairs is termed an "interference." The following points were brought up in the discussion: Prof. F. H. Sibley told what the phrase "patent applied for" meant; W. J. Malcolmson asked if manufacture of an article forestalled getting it patented; Mr. Allison discussed obtaining patents in foreign countries, and C. L. Coggins began the discussion concerning the rights of an employee who invented a device. Prof. J. D. Garver enlarged on the master and servant doctrine and the ethical relation to the engineer.

UNIVERSITY OF MINNESOTA

At the April meeting of the University of Minnesota Student Branch the following members of the faculty were elected to honorary membership: Wm. H. Kavanaugh, John Van S. Martenis, S. Carl Shipley, Frank B. Rowley, and W. H. Martin, all members of the Society. The operation of Large Boilers, by J. W. Parker and published in The Journal for February, was the subject of a review by A. L. Buenger. C. F. Shoop, of the department of experimental engineering, presented a paper on the Standard of the Engineer. He said in part: "The public holds many professions in higher esteem than the engineering profession, and in many respects the public is justified in its opinion. This is due to our apparent lethargy and lack of a spirit of aggressiveness along lines which largely con-

tribute to the molding of public opinion. The public demands that we take a more active part in public problems and issues; public sanction makes it a duty, a responsibility; and our professional dignity and standing is seriously affected by our lack of public spirit. Failure to fulfil duty in respect to public affairs creates a suspicion as to our ability. Many men possess the inert qualifications necessary for a higher standing, yet practically preclude themselves from possible advancement by lack of action. In general, the engineering field is complex and intricate and requires for a full solution of its problems the expenditure of much more mental energy and apparent fatigue than is required in many of the so-called learned professions. Furthermore, its works and achievements do not in general receive the equivalent credit and deserving recognition. A physician can conceal his mistakes, a lawyer gloss over an unfavorable decision; their dealings are to a large extent with individuals; but the engineer dealing with the public must be prepared to withstand public censure. Then if the engineer is not a forcible man of affairs, he cannot carry a compelling recognition to the public mind. Many of us are cognizant of the above facts. We lower our standard by the stain of false impression due to lack of action. Some of us seemingly do not care, while others lack the confidence and persuasive power in speech due to lack of practice. While it is true that fluency in speech is a gift possessed by few, it is believed that the essential elements of public speaking are susceptible of cultivation and with proper training will produce a pliancy and facility of speech to meet the requirement of the engineer. In this cultivation we dare not be so narrow as to place our cultural studies and subjects beneath the technical. It is often advanced by engineering students that the study of cultural subjects is an absurd waste of time. They have the misleading idea that correctness of form and clearness of expression are of secondary importance in the practicing field and that the exercise of such abilities is foreign to their profession. Later in the practicing field they find that, while they can marshal facts and deduce conclusions, they cannot present these deductions with clearness and force. In order to win favorable judgment it is necessary to present thoughts convincingly. In other words, 'English is not only a means for engineers to express themselves in engineering reports, but it is also a means for engineers, as members of a profession, to take their stand with members of other professions as cultured 'men of the world.'"

UNIVERSITY OF MISSOURI

On April 6 the University of Missouri Student Branch held a meeting at which F. A. Fraune gave a talk on Safety Engineering. The lecture was well illustrated with lantern slides.

UNIVERSITY OF NEBRASKA

Prof. J. D. Hoffman, Member American Society of Mechanical Engineers, was the speaker at the March 9 meeting of the University of Nebraska Student Branch, and he chose as his topic, the history of The American Society of Mechanical Engineers from the Beginning. He concluded with an account of the home of the Society in New York, which he illustrated with lantern slides.

On April 7 the subject of discussion was Engineering in Japan, by H. Ichinose and N. Sato. Mr. Ichinose took up the subject of railroads, giving conditions before and after their advent. He illustrated by drawings the types of locomotives used, giving their size, gage, wheel base, etc. At first nothing but American and English locomotives were used, but at present all are made in Japan. The maximum speed is about 40 miles per hour, due to the narrow 42-in. gage; the cost of building is $45,000 to $55,000 per mile. At present there are 7000 miles of railroad over an area equal to that of California. Mr. Ichinose had on exhibition several engineering books in Japanese, among them specifications for locomotives and boilers. Mr. Sato took up manufacturing and by means of lantern projections showed the curious method in which the Japanese do things: how they build bridges, canals, and how they erected their large buildings. He said that great care had to be taken on account of earthquakes. Engineering had been held back in the past on account of lack of iron ore for steel construction work, but they had taken long strides since the Russian War and the present outlook was bright. Chemical engineering was developing rapidly and would exceed all other classes in a short time.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. The published list of "men available" is made up from members of the Society. Notices are not repeated except upon special request. Names and records, however, are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. Further information will be sent upon application.

POSITIONS AVAILABLE

342 Young electrical and mechanical engineer with experience in designing of machinery and power systems for industrial service, construction and erection; must be a good calculator and have executive ability. Location, New Jersey.

401 General superintendent or factory manager for a completely equipped plant for manufacturing grinding wheels of all kinds. Requirements are experience, capacity, reliability and ingenuity. Location, New England. Name strictly confidential. Apply by letter through the Society.

402 Beginning September 1, 1914, one of the leading universities desires well-trained, experienced research assistant in mechanical engineering at salary of $1600 for 12 months' service with one month's vacation on pay. Also experienced instructor in mechanical engineering laboratory practice at salary of $1200 for ten months' service. Full statement of applicant's training and experience, together with recent photograph and list of references, is required. Location, Middle West. Apply through Society.

404 Master mechanic or mechanical engineer, between 35 and 45 years old, in Southern paper mill to take charge of mechanical equipment, operation and maintenance, also mill buildings maintenance. One who has had paper mill experience and in handling Southern white help preferred. Salary, $1800-$2000. Location, eastern Texas.

405 Designer of a line of marine type Diesel engines of from ten to forty-five horse power. Location, New Orleans, La.

406 Two draftsmen; design of railway construction dump cars. Location, New York.

409 Assistant to chief engineer in design of large hydroelectric developments. Must be familiar with all branches of this work, competent to develop designs with only general supervision. Give full record of training and experience, letters of recommendation or references, and salary desired. Location, Pennsylvania. Name confidential. Apply through the Society.

410 Superintendent of building operations, comprising considerable ferro-concrete work, furnace and other constructions. Man preferred between 35 and 55 years of age, who has had extensive experience in large factories in the heavy chemical trade and capable of carrying out details and attending to construction work. Location, Delaware.

411 Engineer, thirty years of age, experienced in production of engineering work, also practical manufacturing. Location, New York.

412 Young, aggressive man capable of managing a manufacturing proposition. Experienced in manufacturing, thoroughly dependable. Could make an investment of $25,000 or $50,000 if he should find the right party. Location, eastern Missouri.

423 Member, wishes to get in touch with a manufacturing concern that would consider manufacturing an entirely new type of automobile wheel which is more durable, more resistant and lighter than the present type of wheel, patents for which have just been applied for.

424 Technical graduate, with several years' experience, will buy an interest in consulting engineering business if earning power can be shown. Location, eastern Pennsylvania preferred.

425 Instructor in machine shop practice for large state university in Middle West. Apply through the Society.

426 American agents wanted on patent specialties for marine purposes, of concern located in Glasgow, Scotland, manufacturing filters, heaters, evaporators and distillers.

MEN AVAILABLE

E-200 Graduate engineer, 15 years' experience in connection with steam, hydraulic and compressed air machinery, wishes to associate with firm engaged in the development of new lines, with compensation arrangement consisting of a nominal salary and royalty on such patentable devices as he may work out.

E-201 Graduate mechanical engineer, age 33, married, at present employed, desires position as manager, engineer in charge, or assistant chief engineer. Wide experience in design, construction and installation of centrifugal pumps and pumping machinery. Has had charge in shop, field, drafting room and sales office.

E-202 Junior member, age 28, graduate mechanical engineer, five years' practical experience in foundry, machine, erecting, and electrical repair shops, drafting room, two and one-half years as switchboard operator on the Panama Canal Zone, desires change. Prefers position as instructor in mechanical engineering. At present employed.

E-203 Member, age 40, specialist in mechanical movements and contrivances, gearing and automatic machinery for special work, would like a position with manufacturing concern desiring a man who will make a study of their machinery and methods, suggest more efficient and economical ways of doing things, invent and design new machines or attachments, and in general improve the quality of the product and decrease costs through the introduction of better mechanical equipment. At present employed in similar capacity.

E-204 Member, nine years' experience in the teaching of mechanism, descriptive geometry, drawing, and engineering mathematics; six years' practice in mechanical engineering work; author of texts in descriptive geometry and mechanism, and articles in engineering journals, successful as teacher, lecturer and manager, desires position in university or technical school.

E-205 Member; production engineer and manager; experienced designer, organizer and producer; familiar with best methods of management, quality and speed production for machinery, metal goods and textiles. Operated under Taylor system and others. Present work completed about June 1, and applicant desires permanent connections with growing or large concern desiring to maintain with its own organization a permanent policy of efficiency and improvement.

E-206 Member, 38 years of age, desires position as superintendent or factory foreman, practical machinist, ten years' experience in charge of shops and departments; competent to organize; thoroughly familiar with all modern manufacturing methods and systems. Location immaterial. Best references.

E-207 Student member, will graduate in June with degree of M.E. from five years' course in a Middle Western university. Desires to start as an apprentice and work up in a factory which specializes in the manufacture of improved farm machinery. Experienced in all types of machinery used on southern Minnesota farms.

E-208 Mechanical and construction engineer, age 38, about to return to the United States from employment in a foreign country. Desires position as designing engineer or superintendent. Technically educated, fourteen years' experience in engineering work, twelve of which in the design, construction and operation of plants for cement manufacture and for the mining and coking of coal. Has held position as chief draftsman, mechanical engineer and superintendent of construction and operation.

E-209 Production engineer, general superintendent or mechanical engineer on manufacturing equipment, with seventeen years' experience. Good executive, with ability and experience in reduction of cost of design and manufacture. Seven years with automobile concern. Age 35; married. At present employed.

E-210 Cornell graduate, associate member, eight years' experience. Desires position as manager or superintendent, assistant or engineer of manufacturing concern or on construction work. Hydro-electric and concrete work a specialty. At present employed. Will go anywhere in United States or abroad.

E-211 Junior, university graduate, four years' experience in drafting room and office. Desires position as assistant to chief engineer or superintendent of manufacturing concern, in or near New York City.

E-212 Associate member, desires position as designing engineer, automatic machinery a specialty, or as erecting engineer. Age 40; married.

E-213 Technical graduate, married, age 32 years, with excellent executive ability. Has had five years' experience in engineering department of large corporation, four years in operating department of same company, and three years as superintendent of plant employing nearly 1000 men. Open for engagement May 1. Well fitted and thoroughly competent for position of manager or general manager of smaller company.

E-214 Junior, graduate mechanical engineer with some drafting experience, two years in charge of mechanical laboratory in a leading university of the Middle West, and at present employed. Desires change to commercial position with good prospects for the future or connection with recognized technical school. Fluent knowledge of German. Location, Eastern States.

E-215 M. I. T. graduate, with experience on instructing staff and four years' experience in efficiency engineering and scientific management in power, manufacturing and auxiliary departments. Desires further work along this line or permanent executive position with concern desiring energy and ability.

E-216 Junior, age 31, single, technical graduate in mechanical and electrical engineering. Desires to make connection with reliable firm of engineers, contractors or large industrial plant. Experiences as assistant in cotton seed oil mill, tests, eight years in design, construction and operation of high and low voltage sub-stations, selling small gas engines, city railway work. Can give best reference and willing to start at moderate salary.

E-217 Technical graduate, 31 years of age, desires position as works manager, mechanical superintendent or efficiency expert with company of consulting engineers or large manufacturing corporation; extensive training and experience in central power station work, designing, purchasing, superintending construction and operating departments; consulting engineering work on large properties; power production investigations; cost reduction; experienced in mill and reinforced concrete construction work. At present employed, but desires a change for advancement.

E-218 Mechanical engineer, technical graduate, age 38, thirteen years' experience in manufacturing lines: shop, operating, drafting, engineering, efficiency, sales, including railroad, Corliss engines, gas engines and producers, saw mill, mining machinery, transmission and special machinery, complete steam and gas power plants.

E-219 Member; wide experience in machinery, metals, processes and their requirements; has filled efficiently positions from machinist to production engineer and knows the cost of production and the value of quality; accustomed to placing rigid contracts at rock bottom prices and can distinguish between low price and low cost, desires a position as purchasing agent and engineer for large establishment.

E-220 Man experienced in drafting room management in the lines of printing press and kindred machinery invites correspondence for his services. Can lead work through designing, pattern work, machinery erecting and testing.

E-221 Superintendent and expert on best machine shop practice and manufacturing methods. For the last two years engaged in selecting and installing equipment for and putting into operating condition in all details one of the most modern machine buildings and manufacturing plants; will soon complete this work. Desires position as production and manufacturing expert, superintendent or manager.

E-222 Member, age 31, married, well informed and of good address, desires change. Thorough operating and commercial experience; college training; assistant to executive, purchasing or administrative officer preferred. Salary, $4,000.

E-223 Junior member, age 29, with twelve years' experience; for past four years, mechanical engineer for large manufacturing concern; experienced in construction work, power plant design and operation, conducting boiler tests; also familiar with purchasing of engineering apparatus and materials. Desires position as mechanical engineer or assistant to manager.

E-224 Cornell graduate, mechanical and electrical engineer with thirteen years' broad experience in design, erection, operation and appraisal of public service and industrial properties, factory maintenance and operation, and sales engineering. Desires a permanent position with consulting engineers or manufacturing company in or near New York City. Appraisal engineering preferred.

E-225 Junior, age 32, engineering training and experience of ten years in engine and boiler manufacture and general plate work, desires position with growing concern. Capable of filling any responsible position in this line.

E-226 Cornell graduate, mechanical and electrical engineer, with twenty years' training and experience in designing, constructing, maintaining, operating and managing. Desires position as mechanical, electrical or efficiency engineer, superintendent or manager.

E-227 Technical graduate, age 30, eight years' experience in gas engine design and manufacture, best references, tireless worker, at present superintendent of gas engine plant, and qualified for position as superintendent, production manager or chief engineer. Would like opportunity for financial interest under agreeable circumstances.

E-228 Member, at present employed, desires to become identified with manufacturing or industrial plant in responsible administrative or executive position; 18 years' varied experience in design and construction of machinery and buildings; remodeling, maintenance and operation of industrial plants and equipment; systematizing of shops and processes along scientific management lines; testing and general plant engineering; familiar with the handling of men, drawing up contracts, purchasing equipment and material, appraising properties; modern methods of manufacturing and marketing product.

E-229 Technical graduate 1912, two years' experience in testing department of large eastern electrical manufacturing concern, desires position in power department of public utility plant or with banking concern handling public utility properties. Location New York City or vicinity preferred.

E-230 Graduate mechanical engineer; age 29; seven years machine shop practice. Drafting experience on large power house design and with large corporation in general engineering, mill building, design, process layouts, machine design and small power house design; also machinery designing engineer. Capable of acting as assistant engineer or assistant chief draftsman.

E-231 Junior member, age 25; technical graduate in mechanical engineering; several years' broad experience as factory inspector for casualty company, and familiar with all classes of manufacturing. Best references.

E-232 Designing engineer with technical training, and shop experience, desires position with live concern in the middle west. Experienced in the design of machine tools, special machinery and tools for reducing the cost of production, presses, dies and other tools for sheet metal stamping. Can offer some patentable improvements in process for light sheet metal stamping.

E-233 Member, owner of patents for internal combustion turbine, desires partner or position where experience in this line is desirable. Has had eighteen years' experience in various engineering fields, executive and inventive ability. Location New York City or vicinity. Salary $2500 to $3000.

E-234 Graduate mechanical engineer; age 24; now employed as assistant superintendent and purchasing agent in a company making gasoline motors and other lines. Desires to get into purchasing or sales line. Has had experience in shop, and as assistant chief engineer in large engine and boiler concern.

E-235 Junior, age 28, graduate mechanical engineer, with ten years shop and office experience in design of Diesel engines, machine shops and general mill engineering. Desires position as assistant to mechanical engineer with firm that can offer something of permanent character. New York preferred.

E-236 Mechanical engineer, with ten years' experience as draftsman, designer, engineer and superintendent, in marine engines, hoisting and conveying machinery, cement machinery and plants, general manufacturing and repair work.

E-237 Sales engineer with record of accomplishment, employed in a managerial position. Seeks correspondence with progressive concerns contemplating the engagement of a technical salesman. Experience covers seven years in foreign and domestic sales. Name confidential. Address through Society.

E-238 Foundry assistant superintendent or engineer. Junior member, age 31, married. Has had 13 years' experience in shop, drawing room and foundry, last four years specializing in foundry efficiency work, installation and operation of equipment; designer of successful molding machinery, pattern mounting methods, etc.; understands melting and mixing of gray iron, malleable and crucible steel. Capable executive, organizer and investigator.

E-239 Stevens graduate, age 28, married. Experienced in general civil engineering, designing, field work in charge of the construction of municipal filtration plant. Three years inspecting fire proof building construction and manufacturing plants, four months designing special hoisting machinery. Desires to change to position that holds prospects for advancement to responsible position.

E-240 Mechanical engineer, age 30, married, with experience in design, construction and erection of steam and gas machinery; production and cost work. Two years in Brazil as head instructor in mechanical experience and consultation work on power plants. Desires position where experience will be valuable to employer.

E-241 Technically trained engineer, age 39, thorough training in machine shops, five years as engineer of steam vessels and large power plants. Master mechanic in charge of all machinery, repairs, building construction and other improvements. Past five years connected with architects' offices as mechanical engineer, designing power plants, heating, ventilating, electrical and plumbing installations for office building, factories, large schools and municipal buildings. Desires position as mechanical engineer with large industrial corporation, to take charge of power plants and equipment. Good executive, accustomed to handling men and experienced on power plant economics.

E-242 Member, age 38, technical graduate, mechanical and construction engineer, about to return to the United States from employment in a foreign country. Desires position as designing engineer or superintendent. Experienced in design, construction and operation of plants for cement manufacture, for mining and coking of coal; chief draftsman, mechanical engineer and superintendent of construction and operation.

E-243 Sales representative established in New York City desires to correspond with manufacturer to secure an additional account. A-1 standing among manufacturers, engineers and contractors.

E-244 Junior member; consulting mechanical engineer with office in Philadelphia wishes to arrange with a company in the vicinity able to use a portion of his time. Ten years' practical experience.

E-245 Technical graduate in mechanical and electrical engineering; six years' shop experience and four years as traveling salesman, desires to represent a first class company in Philadelphia or vicinity as manufacturers' agent.

E-246 Technical graduate, 37 years of age, 15 years exceptionally wide experience in teaching manual training, mathematics, drawing and machine design and mechanical engineering subjects, desires a position with broader outlook. Would accept position in a technical high school, or industrial school as director or head of department, or college.

E-247 Shop manager, specialist in interchangeable work, age 42. Experience in brass foundry. Location, New York district.

ACCESSIONS TO THE LIBRARY

WITH COMMENTS BY THE LIBRARIAN

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary Am Soc. M.E.

DIE ABDAMPF-UND ZWEIDRUCKTURBINEN, Karl Röder. *München, 1913.* Gift of Königl. Technischen Hochschule zu München.

AMERICAN CEMENT DIRECTORY, 1914. *Boston, 1914.*

AMERICAN INSTITUTE OF CONSULTING ENGINEERS. Address by President Alfred Noble. *New York, 1914.* Gift of institute.

AMERICAN MATHEMATICAL SOCIETY. List of Officers and Members, 1914. *New York, 1914.* Gift of society.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION. Pro. 23d annual convention, 1913. *Chicago, 1913.* Gift of association.

AMERICAN SOCIETY OF CIVIL ENGINEERS. List of Members, February 1914. *New York, 1914.* Gift of society.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Journal nos. 7-12, vol. 35, 1913. *New York, 1913.*

ANLEITUNG ZUR AUFSTELLUNG VON BLOCKPLÄNEN, H. Seyberth. *Leipzig, 1914.*

DE L'APPRÊT DES TISSUS DE LAINE PEIGNÉE, Henri Lagache. *Paris, 1914.*

ATLANTIC INTRA-COASTAL WATERWAY. February, 1914. *Philadelphia, 1914.* Gift of Atlantic Deeper Waterway Association.

AUBURN (NEW YORK) WATER BOARD. Report, 1913. *Auburn, 1913.* Gift of Water Board of the City of Auburn.

BRASSFOUNDERS' ALLOYS, J. F. Buchanan. *London-New York, 1914.*

BRAUEREI MASCHINENKUNDE, W. Goslich und K. Fehrmann. ed. 3. *Berlin, 1914.*

BRIEF AND ARGUMENT ON BEHALF OF DEFENDENTS BEFORE THE PUBLIC SERVICE COMMISSION OF THE STATE OF MISSOURI. McGregor-Noe Hardware Company, et. al., Complainants, vs. Springfield Gas and Electric Company and Springfield Traction Company, Defendants. Gift of Calvin W. Rice.

CALCUL DU BÉTON ARMÉ, Ch. Aubry. 2 vols. (text, tables). *Paris, 1913.*

COLUMBIA UNIVERSITY. New Advanced Course in Engineering. *New York.*

DIE DAMPFKESSEL UND IHR BETRIEB, K. E. Th. Schlippe. ed. 4. *Berlin, 1913.*

DIESEL OR SLOW-COMBUSTION OIL ENGINE, G. J. Wells and A. J. Wallis-Tayler. *London, 1914.*

DIE DRAHTSEILBAHNEN, P. Stephan. ed. 2. *Berlin, 1914.*

ELECTROLYSIS CONDITIONS IN SPRINGFIELD, OHIO, REPORT ON. *Springfield, 1914.* Gift of Samuel S. Wyer.

EVOLUTION OF THE INTERNAL-COMBUSTION ENGINE, Edward Butler. *London-Philadelphia, 1912.*

EXCERPT OF THE ANNUAL REPORT OF J. A. BENSEL, STATE ENGINEER AND SURVEYOR ON THE BARGE CANAL. Transmitted to the Legislature, January 26, 1914. *Albany, 1914.* Gift of New York State Engineer.

EXPERIMENT STATION RECORD. General Indexes to vols. 1-12, 13-25, 1889-1901, 1901-1911. *Washington, 1903, 1913.* Gift of U. S. Department of Agriculture Experiment Station.

FABRIKORGANISATION, FABRIKBUCHFÜHRUNG UND SELBSTKOSTENBERECHNUNG, J. Lilienthal. ed. 2. *Berlin, 1914.*

ILLUSTRIRTE ZEITUNG. KAISER JUBILÄUMS NUMMER. 1888-1913. Gift of Hofrat Horst Weber.

JAHRBUCH DER GASTECHNIK, 1912, H. Strache.. *München, 1913.*

MAIN DRAINAGE WORKS PROPOSED FOR NEW YORK, Geo. A. Soper. From Journal of the Boston Society of Civil Engineers, February, 1914. Gift of New York Metropolitan Sewage Commission.

DAS MASCHINENWESEN DER PREUSSISCHE-HESSISCHEN STAATSEISENBAHNEN, C. Guillery. pt. 1. *Berlin, 1914.*

MODERN FILTER PRACTICE, Nicholas S. Hill, Jr. *1913.* Gift of author.

MODERN PUMPING AND HYDRAULIC MACHINERY, Edward Butler. *London, 1913.*

MONTHLY OFFICIAL RAILWAY LIST, December 1913. *Chicago, 1913.*

NATIONAL MARINE ENGINEERS' BENEFICIAL ASSOCIATION OF THE UNITED STATES. Journal of Proc., vol. 13. *Washington, 1914.* Gift of association.

NEW JERSEY HARBOR COMMISSION. 4th preliminary report, February 1914. *1914.* Gift of commission.

PRELIMINARY REPORTS OF THE DISPOSAL OF NEW YORK'S SEWAGE. pts. 11-16. *1914.* Gift of New York Metropolitan Sewage Commission.

RECUEIL DES CAHIERS DES CHARGES UNIFIES DES COMPAGNIES DE CHEMINS DE FER, Pierre Blanc. 1914. *Paris, 1914.*

SPECIFICATION AND ANALYTICAL PROCEDURE FOR 30 PER

CENT HEVEA RUBBER INSULATING COMPOUND. From report of the Joint Rubber Insulation Committee. Gift of Simplex Wire & Cable Co.

STRÖMUNGSENERGIE UND MECHANISCHE ARBEIT, Paul Wagner. *Berlin, 1914.*

DIE TECHNOLOGIE DES MASCHINENTECHNIKERS, Karl Meyer. ed. 3. *Berlin, 1914.*

THEORY OF HEAT ENGINES, William Inchley. *New York, 1913.*

THERMODYNAMISCHE GRUNDLAGEN DER KOLBEN UND TURBOKOMPRESSOREN, Adolf Hinz. *Berlin, 1914.*

THROOP COLLEGE OF TECHNOLOGY. bul. October 1913. *Pasadena, Cal., 1913.* Gift of the Society.

ÜBER TURBINEN MIT DAMPFENTNAHME, August Kriegbaum. *München, 1913.* Gift of Königl. Technischen Hochschule zu München.

U. S. COMMISSIONER OF LIGHTHOUSES. Annual Report to the Secretary of Commerce. 1913. *Washington, 1913.* Gift of commissioner.

U. S. INTERSTATE COMMERCE COMMISSION. Accident bul. nos. 39-43, 45-47. *Washington, 1913.*

VALUATION OF STREET AND INTERURBAN RAILWAY LINES IN THE CITY OF LOS ANGELES, CALIFORNIA. Report no. 1. *Los Angeles, 1914.* Gift of Department of Public Utilities.

DIE VERBRENNUNGSKRAFTMASCHINEN IN DER PRAXIS, Hans Neumann. ed. 2. *Leipzig, 1913.*

DIE VERWENDUNG VON OEL ZUR BERUHIGUNG DER WELLEN, R. Karlowa. *Hamburg, 1888.* Gift of Wm. Paul Gerhard.

ZEITSCHRIFTENSCHAU DER GESAMTEN EISENBETONLITERATUR 1913, A. Fitzinger. *Berlin, 1914.*

EXCHANGES

INDUSTRIAL ARTS INDEX, 1913. *White Plains, 1914.*

INSTITUTION OF AUTOMOBILE ENGINEERS. Proc., vol. 7. *Westminster, 1912-1913.*

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND. Trans., vol. 56. *Glasgow, 1913.*

MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK. Constitution, by-laws, list of members and annual report, 1913. *New York, 1913.*

SÄCHSISCHER DAMPFKESSEL UEBERWACHUNGS VEREIN CHEMNITZ. Ingenieur Bericht, 1913. *Chemnitz, 1913.*

SOCIÉTÉ DES INGÉNIEURS CIVILS DE FRANCE. Annuaire, 1914. *Paris, 1914.*

VICTORIAN INSTITUTE OF ENGINEERS. List of Members, 1911.

TRADE CATALOGUES

ABENDROTH & ROOT MFG. CO., *Newburgh, N. Y.* Handbook no. 41. Root spiral riveted pipe watertube boilers, exhaust heads.

AMERICAN EMERY WHEEL WORKS, *Providence, R. I.* How to prevent grinding wheel accidents (chart).

ANCHOR PACKING CO., *Philadelphia, Pa.* Cat. G, 1913.

BRIDGEPORT BRASS CO., *Bridgeport, Conn.* Handbook for architects, engineers and superintendents. Seamless tubing, 1913.

GOLDSCHMIDT THERMIT CO., *New York.* Reactions, vol. 7, no. 1, 1914.

GOULDS MFG. CO., *Seneca Falls, N. Y.* Cat. F. Pumps and hydraulic machinery, 1910.

HESS-BRIGHT MFG. CO., *Philadelphia, Pa.* Hess-Bright ball bearing hangers. Price list, 1914.

H. W. JOHNS-MANVILLE CO., *Cleveland, Ohio.* J-M Roofing salesman, April 1914.

KENNICOTT CO., *Chicago Heights, Ill.* Products of Kennicott.

LESCHEN, A., & SONS ROPE CO., *St. Louis, Mo.* Leschen's Hercules, April 1914.

MOREHEAD MFG. CO., *Detroit, Mich.* Morehead tilting steam traps, no. 10.

NELSON VALVE CO., *Philadelphia, Pa.* Cat. K, L, S. Bronze valves, iron body valves, steel valves.

SHADALL MFG. CO., *Wauwatosa, Wis.* Description of the aerial ventilator for both rooms.

UNDER-FEED STOKER CO., *Chicago, Ill.* Publicity magazine, March 1914.

WATERHOUSE WELDING CO., *Boston, Mass.* Welding and cutting plants.

YARNALL-WARING CO., *Philadelphia, Pa.* Description of "Lea" V-notch recording liquid meter; reducing coal consumption and increasing the efficiency of the power plant; simplex seatless valves, simplex pipe joint clamps.

UNITED ENGINEERING SOCIETY

CONSERVATION LAW OF THE STATE OF NEW YORK, as amended to the close of the regular session of 1913. *Albany, 1913.*

—— In Relation to Fish and Game and to the Lands and Forests, 1913. *Albany, 1913.* Gift of Conservation Commission.

HISTORY OF THE E. I. DU PONT DE NEMOURS POWDER COMPANY. *New York, 1912.* Gift of E. I. du Pont de Nemours Powder Co.

INDUSTRIAL ARTS INDEX, 1913. *White Plains, 1914.*

INTERNATIONAL WHITAKER, 1914. *London, 1914.*

KATALOG DER BIBLIOTHEK DES KAISERLICHEN PATENTAMTS. vols. 1-3. *Berlin, 1913.*

MOODY'S MANUAL OF RAILROADS AND CORPORATION SECURITIES. vol. I. Railroad Section. *New York, 1914.*

NEBRASKA STATE RAILWAY COMMISSION. Sixth Annual Report to the Governor, 1913. *Lincoln, 1914.* Gift of Nebraska State Railway Commission.

NEW YORK PUBLIC LIBRARY. Annual Report. 1913. *New York, 1914.* Gift of New York Public Library.

OIL, PAINT AND DRUG REPORTER. Green Book for Buyers, January 1914. *New York, 1914.* Gift of Oil, Paint and Drug Reporter.

POSTALIZATION OF THE TELEPHONE AND THE TELEGRAPH. Speech of Hon. David J. Lewis, in House of Representatives, January 16, 1914. Gift of D. J. Lewis.

TRUST LEGISLATION. Hearings before the Committee on the Judiciary, House of Representatives, 63d Congress, on vols. 1-2. *Washington, 1914.* Gift of U. S. House of Representatives Committee on the Judiciary.

GIFT OF J. W. LIEB, JR.

BECK, THEODOR. Beiträge zur Geschichte des Maschinenbaues. ed. 2. *Berlin, 1900.*

IL CODICE ATLANTICO DI LEONARDO DA VINCI. (1 vol. in 6, 3 text, 3 plates.) *Milano, 1894.*

FELDHAUS, F. M. Leonardo der Techniker und Erfinder. *Jena, 1913.*

HERZFELD, MARIE VON. Leonardo da Vinci, Der Denker, Forscher und Poet. *Jena, 1911.*

—— Leonardo da Vinci. Traktat von der Malerei. *Jena, 1909.*

HOUSSAYE, ARSÈNE. Historie de Leonardo de Vinci. ed. 2. *Paris, 1869.*

MCCURDY, EDW. Leonardo da Vinci's note book. *London, 1907.*

MÜNTZ, EUGÈNE. Leonardo da Vinci, Artist, Thinker and Man of Science. 2 vols. *London-New York, 1898.*

TRADE CATALOGUES

KOEHRING MACHINE CO., *Milwaukee, Wis.* The Mixer, January-March 1914.

OZONE PURE AIRIFIER CO., *Chicago, Ill.* Ozone (description); Ozoning the air; Loss by your office stall; What is Ozone?

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ABRIDGED LIST OF OFFICERS AND COMMITTEE CHAIRMEN[1]

JAMES HARTNESS, *President* CALVIN W. RICE, *Secretary*

R. M. DIXON, Finance Committee
H. R. COBLEIGH, House Committee
LEONARD WALDO, Library Committee
L. P. ALFORD, Committee on Meetings
HOSEA WEBSTER, Committee on Membership
C. I. EARLL, Publication Committee
FRED J. MILLER, Public Relations Committee
R. H. RICE, Research Committee
JESSE M. SMITH, Committee on Constitution and By-Laws

LOCAL MEETINGS

Atlanta: J. S. Coon
Boston: R. E. Curtis
Buffalo: W. H. Carrier
Chicago: Paul P. Bird
Cincinnati: J. B. Stanwood
Milwaukee: E. P. Worden
Minnesota: Max Toltz
New Haven: E. S. Cooley
New York: R. V. Wright
Philadelphia: H. E. Ehlers
San Francisco: Robert Sibley
St. Louis: F. E. Bausch

[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1914, and in the January and July 1914 issues of The Journal

PERSONAL NOTES

George A. Orrok, member of the Council, who has been absent from the city for over a year on account of illness, has recovered his health sufficiently to return, but will not resume his duties with the New York Edison Company until the fall. The faithful service which he has rendered in connection with the Gas Power Section will be carried on in connection with the change from a section to a committee with powers similar to those of other sub-committees of the Committee on Meetings.

Ellis Soper, president of the Soper Engineering Company of Chattanooga, Tenn., has been selected as construction engineer for the Market Street bridge of that city. The design will be of concrete and will conform with Government specifications. It will be a low bridge with a lift span over the water channel, the span being about 275 feet long and of steel construction. Mr. Soper's largest work in the South thus far has been the construction of the plant of the Dixie Portland Cement Company at Richard City.

Prof. R. H. Fernald of the University of Pennsylvania was recently appointed consulting engineer of the U. S. Bureau of Mines.

T. Kennard Thomson addressed a meeting of the Maritime Association of the Port of New York on May 4, giving an outline of a plan for a really greater New York. This contemplates the annexation of Manhattan to Long Island by filling in the East River, as well as other equally important topographical changes of the harbor and water front. Mr. Thomson estimates that this could be done in five years.

Frank B. Gilbreth has been appointed Honorary Vice-President to represent the Society at the opening of the new society house of the Verein deutscher Ingenieure on June 5. Mr. Gilbreth is now abroad investigating conditions of management in Germany.

H. Alfred Ellis has been elected president of the Light Railway Equipment Company of Chester, Pa. He was formerly associated with the Orenstein-Arthur Koppel Co., Koppel, Pa., in the capacity of general superintendent.

Albert W. Thompson has accepted the position of managing engineer of The G. M. Parks Company, Fitchburg, Mass. He was until recently connected with the Saco-Lowell Shops, Lowell, Mass., as superintendent.

John Lathrop Gray, formerly associated with the Tide Water Oil Co., Bayonne, N. J., as assistant general superintendent, is now identified with the Pierce Oil Corporation, St. Louis, Mo., as manager of the refining and producing departments.

George C. Thomas has been appointed superintendent of The Singer Company, Podolsk, Moscow, Russia. He was formerly connected with the Bridgeport, Conn., factory of the company as assistant superintendent.

Edmund Mackenzie has taken a position with R. Blakstad, who is one of the foremost engineers and promoters of Norway, as supervising engineer on construction work on high head hydraulic developments, power transmission, substations, factories, etc., with headquarters at Kristiania.

M. H. Roberts is affiliated with Mead Johnson Company, manufacturing chemists, Jersey City, N. J., as consulting engineer.

STUDENT BRANCHES

Members of student branches are requested to notify the Secretary of any change in address as promptly as possible, in order to facilitate receipt of The Journal.

COLUMBIA UNIVERSITY

T. E. Sperry lectured on the Gyroscope for Marine Purposes at a meeting of the Mechanical Engineering Society of Columbia University in conjunction with the Electrical Engineering Society on April 14. The points covered were the advantages of the gyro-compass over the magnetic compass; the operation of repeater compasses located at different parts of the ship and their control by a master compass situated below in a well protected place; the adjustments necessary to correct for the speed of the ship; the use of the gyroscope as a stabilizer for ships and aeroplanes. The lecture was illustrated with lantern slides.

On May 6 the following officers were elected for the year 1914-1915: H. T. Allen, chairman; W. L. Garrison, vice-chairman; A. S. Henry, secretary; J. T. Hanlon, treasurer.

KENTUCKY STATE UNIVERSITY

The Economic Use of Coal by Communities was the subject of a paper by Prof. John T. Faig, Mem.Am.Soc.M.E., before the Kentucky State University Student Branch on April 18. The author's idea was to convert bituminous coal, which causes so much damage to our cities from smoke and which is not an ideal fuel for residences, into two ideal fuels by means of coking ovens, coke and coal gas. These products are better than coal as fuel for the house or factory. The other products of the coking oven, tar, benzol and ammonia sulphate, are each valuable to the industrial world: benzol will find a market as a substitute for gasolene; figures given by Professor Faig showed that by buying coal at prices prevailing in the Ohio Valley the coke and coal gas can be sold at prices within reach of all and the sale of the other products will make it a profitable business.

LELAND STANFORD JUNIOR UNIVERSITY

On April 28 the Stanford Mechanical Engineering Society elected the following officers to serve from September to December 1914: J. A. Gibb, chairman; L. Swayne, vice-chairman; C. L. Addleman, secretary-treasurer.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

At the meeting of Massachusetts Institute of Technology Student Branch on April 22, H. F. J. Porter, Mem.Am.Soc.M.E., read a paper on Fire Traps—Fire Escapes—Fire Drills versus Sectional Buildings.

On April 29 the society held its annual banquet and election of officers: F. G. Purinton was chosen chairman; N. E. Kimball, vice-chairman; H. E. Morse, secretary; G. A. Palmer, treasurer; and F. L. Cook, W. R. Hanchett, O. C. Norris, governing board. Charles T. Main, Mem.Am.Soc.M.E., was the first speaker of the evening and chose as his topic, Professional Ethics. He was followed by William Kent, Mem.Am.Soc.M.E., who defined the word "engineer"; Prof. G. B. Haven, Mem.Am.Soc.M.E., who gave the seniors advice on starting on their business careers. Prof. G. E. Russell then told of some interesting discoveries concerning the Pyramids, and Prof. E. F. Miller, Mem.Am.Soc.M.E., closed the evening with a talk concerning the Society.

On May 5 H. J. DeBear, of the Maxwell Automobile Company, gave an illustrated talk on the complete process of manufacture of the automobile from the ore to the finished product. The author dwelt at some length on the testing of the raw materials and the finished product, and showed many of the parts in process of manufacture. Moving pictures were used to illustrate the lecture.

PENNSYLVANIA STATE COLLEGE

On April 23 H. L. Swift read a paper before the Student Branch of Pennsylvania State College on The Manufacture of Glass by Machinery. He followed the process through its different stages from the batch-making room to the packing house, and told of the operations where machinery has re-

placed hand labor with considerable saving in the cost of manufacture and betterment of quality.

At the May 15th meeting, W. D. Garman presented a paper on The Machining and Assembling of Steam Engine Parts, and the following offered discussion: Prof. J. A. Moyer, Mem.Am.Soc.M.E., Professor Bates, and C. F. Kennedy.

POLYTECHNIC INSTITUTE OF BROOKLYN

On April 25 the Polytechnic Institute Student Branch held its third annual banquet. The speakers were Fred. W. Atkinson, President of the Institute, Samuel M. Tucker, Wm. D. Ennis, Mem.Am.Soc.M.E., and Calvin W. Rice, Secretary of the Society.

At a meeting on May 2 the following officers were elected for the ensuing year: M. Van Valkenburgh, chairman; S. P. Blakeman, vice-chairman; Samuel Kobre, secretary; C. J. Koff, treasurer. Leon A. Eben read a paper on Parliamentary Procedure, which was discussed by A. A. Adler, Mem.Am.Soc.M.E., and Messrs. Tyler, Sand, Postman, Isenberg and Merkt.

RENSSELAER POLYTECHNIC INSTITUTE

At a meeting of the Rensselaer Polytechnic Institute Student Branch on April 30, R. L. Manier lectured on the Production of Carbureted Water Gas and illustrated his talk with lantern slides. C. E. Davies presented a paper on Up-to-Date Office Methods in Large Manufacturing Plants.

STATE UNIVERSITY OF IOWA

The Student Branch of the State University of Iowa held a joint meeting on April 21 with the Electrical Engineering Society and the Compass Club, at which Prof. S. M. Woodward, Mem.Am.Soc.M.E., read a paper on Flood Prevention In and Around Dayton, Ohio. The author is one of the consulting engineers employed on the project. The lecture was profusely illustrated by slides showing flood conditions, the results, and the methods suggested to prevent a recurrence.

At a meeting of the branch on May 5, H. J. Kicherer gave an illustrated talk on Automobile Manufacturing.

STEVENS INSTITUTE OF TECHNOLOGY

The Stevens Engineering Society held a debate with the Sibley College Student Branch on May 11. The subject was Resolved, That Public Utilities of Municipal Scope Should be Owned and Operated by the Municipality (electric light, gas and water plants only to be considered). Benjamin P. Goldman of Sibley College upheld the affirmative, and divided his arguments as follows: (*a*) public utilities are natural monopolies and, as such, are dangerous; (*b*) regulation of public utilities by commission has to date proved unsatisfactory; (*c*) why deal with a poor subterfuge such as regulation when the community will be benefited financially by municipal ownership. In proving the last two points the affirmative cited instances where the rates charged for electricity had been reduced in the case of municipal ownership from $0.125 to $0.05 per kw-hr., while the Chicago Lighting Company had declared a dividend of 24 per cent during the last year. The negative side was treated by C. H. Colvin of Stevens under the following heads: (*a*) the proposition should be viewed from the point of cost of service ratio; (*b*) the elimination of profits is more than made up for by the increase in the cost of materials, running expenses and wages under municipal ownership; (*c*) graft becomes easier under municipal ownership than under private operation; (*d*) that data for comparing the relative cost of production under the two forms of ownership are unreliable since the factors of depreciation and taxes are not generally taken into account in preparing these estimates under municipal ownership, while they are under private operation. Frederick R. Hutton, Past-President and Honorary Secretary of the Society, Charles Whiting Baker, Mem.Am.Soc.M.E., and Mr. March, Stevens 1914, acting as judges, decided unanimously in favor of the affirmative.

UNIVERSITY OF CALIFORNIA

On April 21 the University of California held its final meeting of the year, and the following officers were elected: A. C. Moorhead, chairman; L. T. Kennedy, vice-chairman; H. L. McLean, secretary; B. R. Abbott, treasurer. L. T. Kennedy discussed a paper, Power from Mercury Vapor, which appeared in the Transactions of the American Institute of Electrical Engineers; and W. W. Penniman, Surface Combustion, which appeared in the American Gas Institute Journal.

UNIVERSITY OF COLORADO

The University of Colorado Student Branch, at a meeting on May 13, elected the following officers for the coming year: L. J. Brady, chairman; Ben Christian, vice-chairman; S. S. Cooke, secretary-treasurer.

UNIVERSITY OF ILLINOIS

On April 16 at a meeting of the University of Illinois Student Branch, M. E. Hodgins, of the Goodrich Rubber Company, gave an interesting talk on rubber, during the course of which he traced the growth of the industry from the time of Columbus to the present day. On May 7 Prof. A. C. Willard spoke on The Organization of the Engineering Office of the Chief Quartermaster Corps of the United States Army, with which he was formerly connected.

UNIVERSITY OF MISSOURI

The Missouri University Student Branch held a meeting on April 20 at which S. G. Goodman presented a paper on Fire Prevention and Fighting in Our Shops and Factories. P. R. A. Notting followed with a paper on Aerial Motors and the Trouble That Had to Be Overcome in Some of Them. On May 4 an illustrated lecture was delivered before the electrical and mechanical engineering branches on the Engineering Societies Building, New York.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing positions for members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. The published list of "men available" is made up from members of the Society. Notices are not repeated except upon special request. Names and records are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. Further information will be sent upon application.

POSITIONS AVAILABLE

420 Chief engineer with jurisdiction in all engineering questions over plant, equipment, mechanical methods and products. To qualify, applicant should have technical training and wide experience, chiefly in metal working of the lighter and finer kinds, also in planning construction of buildings and designing and operating of power plants. Name confidential; apply through the Society.

507 Three railway construction engineers with a number of years experience, about 35 or 40 years of age, for positions with government railway in New South Wales. £100 traveling expenses allowed to Sydney. Salary £590 per annum.

508 Mechanical and electrical engineer, who understands some Spanish, and capable of taking charge of a producer gas power plant in Ciudad, Bolivar, Venezuela. Traveling expenses paid to Venezuela.

509 Technical graduate desired who is familiar with the theory, present practices and the manufacturing of centrifugal and turbine pumps. Must have had actual experience either as chief or assistant designer. Ability to estimate on costs. Give full details covering education, shop and business experience, references, age, etc. Name confidential; apply through the Society.

510 Man of engineering training between the ages of 25 and 35, with experience in the productive or executive de-

partments of large factories, to fill position as assistant to head of a manufacturing department in factory in New Jersey. Salary about $1500 per year, depending upon qualifications. Give detailed history of business career. Apply through the Society.

511 Energetic, young man, well educated, with a knowledge of mechanics, and a good correspondent in sales department of a large manufacturing company in New England. Graduate mechanical engineer with some commercial experience preferred. A full reply giving age, whether married or single, experience, present occupation, references and salary expected will receive attention and will be treated confidentially. Name confidential; apply through the Society.

514 Draftsman and maintenance engineer for service and maintenance department of large electrical supply concern. Location, New York.

518 Consulting engineer controlling valuable patents relating to gas engines desires to become associated with engine building concern for the development of the engines covered by these patents.

519 Mechanical, metallurgical and chemical engineer competent to take charge of a research laboratory, to make tests of the strength of materials and devise special processes, etc. Exceptional opportunity. Location, Maryland. Name confidential; apply by letter.

520 Assistant to executive. Experience required in handling men; competency to design small and medium size machinery for strictly interchangeable work; familiarity with modern shop practice and tooling. Salary $2500 to $3000. Location, Maryland. Name confidential.

MEN AVAILABLE

F-500 Mechanical engineer, graduate of a leading university, wishes position in which good future can be anticipated. Age 30; married; nine years experience drafting, designing, construction and maintenance work; considerable electrical experience, in charge large high-tension apparatus.

F-501 Technical graduate, age 37, with continuous experience since graduation in engineering work, chiefly in design of power plant, mining and mill machinery. More than ten years in charge of work as chief draftsman and chief engineer.

F-502 Graduate in mechanical engineering with some shop and drawing room experience desires instructorship in mechanical engineering branches for the coming school year.

F-503 Assistant to executive; graduate mechanical engineer, '09, with business experience, organization, management. Junior, age 28, married.

F-504 M. I. T. graduate, with experience on instructing staff and four years experience in efficiency engineering and scientific management in power, manufacturing and auxiliary departments. Desires further work along this line or permanent executive position with concern desiring energy and ability.

F-505 Associate-Member, technical graduate, seven years experience, recently completed work as mechanical engineer in charge of erection work for smelter and large power plant. At present in charge of plant, transmission line and repair shops. Desires similar position, or in designing office.

F-506 Junior, university graduate, at present occupied in teaching mechanical engineering laboratory practice in one of the large eastern technical schools, desires employment for the four summer months, preferably with efficiency engineers, or company installing scientific management. Practical experience in central station work. Well recommended.

F-507 Junior, age 28, graduate mechanical engineer, desires position with engineering firm or industrial plant. Location immaterial. Five years experience in design, testing, operation, and management of power machinery. Steel mill and electrical experience.

F-508 Specialist in the practical manufacture of pumps, steam, gas, oil, gasolene and kerosene engines; sales work and power plant construction, and until recently vice-president of a million dollar corporation manufacturing all forms of pumps and prime movers. Desires connection with concern of some importance in capacity of engineer, or preferably, sales work.

F-509 Graduate mechanical engineer; age 24; now employed as assistant superintendent and purchasing agent in a company making gasolene motors and other lines. Desires to get into purchasing or sales work. Has had experience in shop, and as assistant chief engineer in large engine and boiler concern.

F-510 Junior, graduate mechanical engineer; age 24; desires position in connection with machine tools or prime movers. Has had responsible positions as designer and mechanical engineer. Seeks opportunity for greater development. Salary desired, $1500, but experience to be gained and opportunity for advancement will be considered first. Best references. New York preferred. Address through the Society.

F-512 Member, age 34, professor of mechanical engineering subjects; would prefer small school which is growing rapidly. Graduate of Cornell University; eight years experience in engineering, from draftsman to chief engineer; three years teaching in one of the largest engineering schools; can handle any subjects in mechanical engineering course; especially strong in experimental engineering. Best references. Desires change to assume more responsibility.

F-513 Associate-Member, age 36; government, railroad and factory connections; competent to take care of plant engineering, also work incident to control of materials; some experience in appraisal, purchase and cost departments.

F-514 Junior, age 31; seven years experience in gas and electric business; wishes to locate in Middle West in same line of work. At present employed.

F-515 Member, at present employed, desires to become identified with manufacturing or industrial plant in responsible administrative or executive position; 18 years varied experience in design and construction of machinery and buildings; remodeling, maintenance and operation of industrial plants and equipment; systematizing of shops and processes along scientific management lines; testing and general plant engineering; familiar with the handling of men, drawing up of contracts, purchasing equipment and material, appraising properties; modern methods of manufacturing and marketing product.

F-516 Member, with exceptional technical training, both mechanical and electrical; five years experience in research work on steam turbines, centrifugal air compressors and jet pumps; four years complete charge of designing, manufacturing, testing and installing vacuum cleaner systems, including the development of a complete line of portable and stationary vacuum cleaning machines; desires position with a good firm of consulting engineers, with prospect of ultimate interest in the firm; or would consider position with good manufacturing firm. At present employed.

F-517 Junior, age 38; sales engineer, experienced in handling high-grade power transmission and mechanical specialties; desires to represent manufacturer; eastern territory in United States, or England preferred.

F-518 Member; technical graduate, 31 years of age, desires position as works manager, mechanical superintendent or efficiency expert with company of consulting engineers or large manufacturing corporation; extensive training and experience in central power station work, designing, purchasing, superintending construction and operating depart-

ments; consulting engineering work on large properties; power production investigations; cost reduction; experienced in mill and reinforced concrete construction work. At present employed, but desires a change for advancement.

F-519 Sales engineer, Junior, progressive with successful selling experience; wishes connection with high-class manufacturing company desirous of representation in Chicago and Middle West.

F-520 Executive, technically educated as a mechanical engineer, who, under titles of assistant vice-president and secretary, has served as a general utility man for well-known manufacturers of machinery; duties included sales, advertising, development of new ideas, pushing out work and general office management; seeks a responsible position where a wide engineering knowledge will be of value.

F-521 Associate-Member, age 29, married, graduate M.E. 1908; experience in designing and developing new and original devices in machine shop; erections and installations, testing and selling. Good knowledge of water works and power plant equipment. Desires a position of responsibility or where the outlook for the future is bright for the man who can prove good.

F-522 Summer Position—instructor of mechanical engineering in an Eastern Institution, desires a shop position; age 26; four years experience in gas engine manufacture; available about June 15th.

F-523 Member, with European technical education, desires connection with large industrial or manufacturing firm. Thirteen years experience in various branches of engineering, including the design and development of special machinery and process equipment; layout, design, construction, equipment and maintenance of manufacturing and industrial plants. Conversant with the most modern, efficient and economical methods; has executive ability, a good handler of men, willing to assume responsibility, and able to take independent charge of industrial engineering work from the preliminary investigation to the completion of the work. Now employed.

F-524 Member, technical graduate, desires position as works manager or general superintendent, experienced in foundry and machine shops, a good executive and manager of men.

F-525 Mechanical engineer, age 27, four years experience as a machinist, two as assistant chief engineer of a firm manufacturing engines, boilers, etc.; knows how to work harmoniously with other men and has executive ability. Would consider position with a progressive firm in charge of department, or in charge of production and time setting. At present employed.

F-526 Executive engineer, recently general manager of an important manufacturing business, rigid experience in carrying out large operations. Has been successful in controlling men and reducing cost of handling material; 35 years of age.

F-527 Sales representative established in New York City desires to correspond with manufacturer to secure an additional account. A-1 standing among manufacturers, engineers and contractors.

F-528 Cornell graduate, mechanical and electrical engineer with broad experience in design, erection, operation and appraisal of public service and industrial properties, factory maintenance and operation, and sales engineering. Desires a permanent position with consulting engineers or manufacturing company in or near New York City. Appraisal engineering preferred.

F-529 Member, at present employed, desires to be identified with manufacturing or industrial plant in responsible administrative or executive position; 18 years varied experience in design and construction of machinery and buildings; remodeling, maintenance and operation of industrial plants and equipment; systematizing of shops and processes along scientific management lines; testing and general plant engineering; familiar with the handling of men, drawing up contracts, purchasing equipment and material, appraising properties; modern methods of manufacturing and marketing product.

F-530 Cornell graduate in mechanical engineering, seven years continuous experience; consulting engineering officer, preparation of plans, specifications, supervision of installations; also management of hardware and tool manufacture.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary Am. Soc. M. E.

American Society of Agricultural Engineers. Trans. vol. 5, 1911. *Urbana, 1912.* Gift of society.

American Telephone and Telegraph Company. Cat. of Accounting Library, vol. 1. *New York, 1914.* Gift of company.

American Type Founders Company. Guide to the exhibit of the typographic library and museum, at the second national printing exposition, Grand Central Palace, April 18-25, 1914. Gift of company.

Argument before U. S. Senate Committee on Banking and Currency in support of Senate bill No. 3895 to regulate the use of the mails, telegraph and telephone by stock exchanges, March 16, 1914, Samuel Untermyer. *New York.* Gift of author.

Die Berechnung der frei aufliegenden, rechteckigen Platten, Heinrich Leitz. Forscherarbeiten auf dem gebiete des Eisenbetons, pt. 23. *Berlin, 1914.*

Beton Taschenbuch, 2 vols., 1914. *Berlin, 1914.* Gift of Zement und Beton.

Bevel Gears, Plain Practical Directions for Drawing, Sizing and Cutting. *Manchester, 1891.*

Brief and Reply Brief Submitted on Behalf of the New York Stock Exchange to the Senate Committee on Banking and Currency, March 5, 30, 1914. Gift of New York Stock Exchange.

Carnegie Institute of Technology. General cat. 1913-1914. *Pittsburgh, 1913.* Gift of the Society.

Cement World. Vols. 3-6. *Chicago, 1909-1913.*

Compressed Air, Theodore Simons. *New York. McGraw-Hill Book Co., 1914.*

A book designed primarily for students which omits the extensive description of every existing type of compressor and the countless appliances using compressed air. It is well provided with problems for the students.

Construction of the House Office Building, report of the commission to direct and supervise. *Washington, 1912.* Gift of John D. Trenor.

The Diesel Engine. *St. Louis, 1913.* Gift of Basch-Sulzer Bros. Diesel Engine Co.

Engineers' Club of Dayton. General Information, By-Laws 1914. *Dayton, 1914.* Gift of club.

Erecting Work, H. E. Collins. *New York, 1908.*

Hilfsbuch für den Apparatebau, E. Hausbrand. ed. 2. *Berlin, 1909.*

History of the Singer Building Construction, its progress from foundation to flag pole, edited by O. F. Semsch. *New York, 1908.* Gift of Singer Sewing Machine Co.

Hydraulic Data, H. D. Coale. *1913.* Gift of Pacific Tank & Pipe Co.

Hydraulics for Engineers and Engineering Students, F. C. Lea. ed. 2. *New York, 1907.*

HYDRAULIK, Philipp Forchheimer. *Leipzig-Berlin, 1914.*

ILLINOIS WATER SUPPLY ASSOCIATION. Proc. of second meeting, 1910. *Urbana, 1910.*

INSTALLATION OF LYMAN PIERSON POWELL AS PRESIDENT OF HOBART COLLEGE AND WILLIAM SMITH COLLEGE, November 14, 1913. Gift of Hobart College.

INSTITUTE OF RADIO ENGINEERS. Year Book, 1914. *New York, 1914.* Gift of institute.

JAHRBUCH DER WISSENSCHAFTLICHEN GESELLSCHAFT FÜR FLUGTECHNIK. vol. 2, 1913-1914, pts. 1-2. *Berlin, 1914.*

LIFE AND PUBLIC SERVICES OF ANDREW S. DRAPER, Thos. E. Finegan. *Albany, 1914.* Gift of University of the State of New York.

MECHANICS AND HEAT, W. B. Anderson. *New York, 1914.*

MILWAUKEE. SMOKE INSPECTOR. Annual Report, 1913. *Milwaukee, 1913.* Gift of Smoke Inspector.

THE MNEMONIC SYMBOLIZING OF STORES UNDER SCIENTIFIC MANAGEMENT, H. G. Benedict. Gift of H. Uheland.

MODERN STEAM TRAPS (ENGLISH AND AMERICAN), their construction and working, Gordon Stewart. *London, 1907.*

THE NAVY AND MARINE CORPS REGISTER, January 1, 1914. *Washington, 1914.* Gift of U. S. Navy Dept.

NEW YORK CENTRAL AND HUDSON RIVER RAILROAD COMPANY. Report of the Board of Directors to the Stockholders 1913. *New York, 1913.* Gift of company.

NEW YORK (STATE) AUTOMOBILE BUREAU. Annual Report of the Secretary of State, 1913. *Albany, 1914.* Gift of bureau.

OHIO ELECTRIC LIGHT ASSOCIATION. Proc. of 19th annual convention, 1913. *1913.* Gift of association.

PRESENT STATUS OF THE WATER POWERS OF WISCONSIN, Daniel W. Mead. *1914.* Gift of author.

DIE PRINCIPIEN DER WÄRMELEHRE, E. Mach. ed. 2. *Leipzig, 1900.*

PUMPEN UND KOMPRESSOREN, H. Haeder. ed. 3, vol. 1. *Wiesbaden, 1914.*

RAILWAY STATISTICS OF THE UNITED STATES OF AMERICA, 1913, Slason Thompson. *Chicago, 1914.* Gift of author.

RESTORATION OF THE WHITE HOUSE. Message of the President of the United States transmitting the report of the architects. *Washington, 1903.* Gift of John D. Trenor.

RIO DE JANEIRO (BRAZIL) MINISTERIO DA VIAÇÃO E OBRAS PUBLICAS. Relatorio apresentado ao Presidente da Republica dos Estados Unidos do Brazil, J. B. Gonçalves. *Rio de Janeiro, 1913.* Gift of Ministerio da Viaçao e Obras Publicas.

SAFETY AND SANITATION, M. W. Alexander. *1913.* Gift of National Founders' Association.

SERVICE STATION A BUSINESS INSTITUTION. Reprinted from The Commercial Vehicle, Apr. 15, 1914. Gift of International Motor Company.

STEEL FOUNDRY, J. H. Hall. *New York, McGraw-Hill Book Co., 1914.*

The author states in his preface that his object is "to set forth the metallurgy of the steel foundry from the standpoint of the engineer, . . . whose usefulness consists in prescribing the cheapest means of producing objects or structures of sufficient excellence for the purposes for which they are intended." A chapter is given up to heat treatment and annealing, and one to "building up" impurities in steel. There have been few works on steel castings, and this seems a valuable addition to the literature of the subject.

TAR FORMING TEMPERATURES OF AMERICAN COALS, O. C. Berry. University of Wisconsin. bul. no. 635. *Madison, 1914.* Gift of A. G. Christie.

TASCHENBUCH DER LUFTFLOTTEN. 1 Jahrgang, 1914. *München, 1914.*

TECHNISCHE THERMODYNAMIK, W. Schüle. ed. 2, "Technischen Wärmemechanik." vols. 1-2. *Berlin, 1912, 1914.*

VEREIN DER DEUTSCHEN ZUCKER-INDUSTRIE. General Register der Zeitschrift. 1903-1912. *Berlin.* Gift of society.

VEREIN DEUTSCHER INGENIEURE. Inhaltsverzeichnis der Jahrgange 1904-1910, vols. 48-54 der Zeitschrift. *Berlin, 1912.* Gift of society.

VORLESUNGEN ÜBER TECHNISCHE MECHANIK, Aug. Föppl. vols. 1, 3-5. *Leipzig-Berlin, 1907, 1909, 1911.*

DIE WERKZEUGMASCHINEN, Hermann Fischer. vol. 2. *Berlin, 1901.*

WESTERN SOCIETY OF ENGINEERS. Year Book, 1914. *Chicago, 1914.* Gift of society.

EXCHANGES

AMERICAN GAS INSTITUTE. Proc. vol. 8, 1913. pts. 1-2. *New York, 1914.*

NATIONAL ASSOCIATION OF COTTON MANUFACTURERS. Trans. No. 95. *Boston, 1914.*

U. S. NAVAL OBSERVATORY. Annual Report, 1913. *Washington, 1913.*

TRADE CATALOGUES

AMERICAN BLOWER CO., *Detroit, Mich.* Bul. no. 35, pitot tube and fan testing, January 1914.

BROWN INSTRUMENT CO., *Philadelphia, Pa.* Cat. no. 9, Brown pyrometers.

CARBONDALE MACHINE CO., *Carbondale, Pa.* Bul. no. 11, modern distilled water can ice plant, February 1911; bul. no. 12, ice making with the Carbondale evaporator system, February 1911; bul. no. 14, ten to one ice plant, August 1913; bul. no. 16, helping the competitor, June 1913; machinery for the manufacture and liquefaction of carbonic acid gas, 1914.

CHAPMAN VALVE MANUFACTURING CO., *Indian Orchard, Mass.* Cat. and price list, no. 31.

DAVIS-BOURNONVILLE CO., *Jersey City, N. J.* Oxy-acetylene welding and cutting apparatus, 31 pp.

ELECTRIC STORAGE BATTERY CO., *Philadelphia, Pa.* Handbook H L, low voltage isolated electric plants for lighting and power with Chloride Accumulator, March 1914; Handbook IP, chloride accumulator for use in 110 volt isolated lighting and power plants, August 1912.

ELECTRIC WEIGHING CO., *New York, N. Y.*, messiter conveyor scales.

FAIRBANKS-MORSE & CO., *Chicago, Ill.* Bul. 27, direct-current type CP motors and generators; bul. 29, direct-current type TRC motors and generators; bul. 202H, alternating-current type B constant speed induction motors; bul. 210, internal starter motors.

KENT MILL CO., *Brooklyn, N. Y.* Bul. 39, maxecon mill; bul. 40, perfectecon separator; bul. 41, mexecon mill grinding plant.

KEWANEE BOILER CO., *Kewanee, Ill.* Cutting coal costs.

MAX AMS MACHINE CO., *Mt. Vernon, N. Y.*, seal of safe.y, 1914.

NORTHWESTERN EXPANDED METAL CO., *Chicago, Ill.* Expanded metal construction, May 1914.

SANGAMO ELECTRIC CO., *Springfield, Ill.* Bul. 37, sangamo meters, February 1914.

TIMKEN ROLLER BEARING CO., *Canton, Ohio.* Timken magazine, March 1914.

UNDER-FEED STOKER CO. OF AMERICA, *Chicago, Ill.* Publicity Magazine devoted to the interests of The Jones Stoker, April, May 1914.

WAGNER ELECTRIC MANUFACTURING CO., *St. Louis, Mo.* Bul. no. 104, manual of electrical testing, March 1914.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ABRIDGED LIST OF OFFICERS AND COMMITTEE CHAIRMEN[1]

JAMES HARTNESS, *President* CALVIN W. RICE, *Secretary*

R. M. DIXON, Finance Committee
H. R. COBLEIGH, House Committee
LEONARD WALDO, Library Committee
L. P. ALFORD, Committee on Meetings
THEO. STEBBINS, Committee on Membership
C. I. EARLL, Publication Committee
FRED J. MILLER, Public Relations Committee
R. H. RICE, Research Committee
JESSE M. SMITH, Committee on Constitution and By-Laws

LOCAL MEETINGS

Atlanta: J. S. Coon
Boston: R. E. Curtis
Buffalo: W. H. Carrier
Chicago: Paul P. Bird
Cincinnati: J. B. Stanwood
Milwaukee: E. P. Worden
Minnesota: Max Toltz
New Haven: E. S. Cooley
New York: R. V. Wright
Philadelphia: H. E. Ehlers
San Francisco: Robert Sibley
St. Louis: F. E. Bausch

[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1914, and in the January and July 1914 issues of The Journal

PERSONAL NOTES

Nicholas S. Hill, Jr., consulting engineer of New York, sails for Europe on July 7 for the purpose of making an investigation and study of the German and English water and sewage plants. He will return to this country about September 1.

Jay G. Coutant, formerly engineer of plant of the Lima Locomotive Corporation, Lima, Ohio, who has specialized in the burning of powder fuel and water gas, has taken up the same work for the Railway Materials Company, Chicago, Ill.

A. A. Potter, for several years professor of steam and gas engineering at the Kansas State Agricultural College, was made dean of the engineering division and director of the engineering experiment station of the same institution. Mr. Potter will still retain the professorship in steam and gas engineering.

Daniel Webster Mead, professor of engineering in the University of Wisconsin, Madison, Wis., has been appointed a member of a Board of Engineers for the prevention of floods in Eastern China through a $20,000,000 reclamation project.

Alexander G. Christie, associate professor of steam engineering, University of Wisconsin, has been appointed associate professor of mechanical engineering in the College of Engineering which Johns Hopkins University is now organizing and building.

Harry L. Brunger has become affiliated with the Aultman-Taylor Machinery Company, Mansfield, Ohio. He was until recently in the employ of M. Rumely Company, La Porte, Ind., in the capacity of chief draftsman.

Theodore A. Leisen has been appointed general superintendent of the Board of Water Commissioners of Detroit, Mich. He was formerly associated with the Louisville Water Company, Louisville, Ky., as chief engineer and superintendent.

Arthur M. Crane, late sales manager of the Permutit Company, New York, has returned to the New York Continental Jewell Filtration Company, New York, and will have charge of the pressure filter business.

Arthur J. Beerbaum has accepted a position with the Western Electric Company, Chicago, Ill., in the plant engineering department. He was formerly associated with The Arnold Company of the same city, in the capacity of draftsman.

William Floyd Lee, chief engineer of C. W. Hunt Company, Inc., West New Brighton, S. I., N. Y., at a recent meeting of the Board of Directors, was elected vice-president and chief engineer of the company.

Frederic E. Pierce has terminated his connection with The New Jersey Zinc Company, New York, in whose employ he has served for over 15 years in various capacities, for the latter part as chief engineer, and has opened an office to engage in consulting work in civil and metallurgical engineering.

R. H. Danforth, who has been for the past six years connected with the U. S. Naval Engineering Experiment Station and the Post Graduate Department of Engineering of the U. S. Naval Academy, Annapolis, Md., has been appointed professor of mechanics and hydraulics at Case School of Applied Science, Cleveland, Ohio.

STUDENT BRANCHES

KANSAS STATE AGRICULTURAL COLLEGE

On May 18, Leland C. Angevine, chairman of the Student Branch at the University of Kansas, gave a talk on the work of his Student Branch, telling of its success and general plan.

Chief Engineer Polling gave an illustrated lecture on the Metropolitan Power Company of Kansas City, Mo., explaining in detail the operation of the units of power production and the method of handling the condensors.

R. J. Taylor, senior student, gave a discussion of the Kansas City, Mo., Water Supply, explaining the treatment of the water to remove the impurities and render it fit for use.

LEHIGH UNIVERSITY

On May 19, Lehigh University Student Branch elected the following officers: A. V. Bodine, president; E. P. Humphrey, bursar; H. A. Brown, secretary; P. G. De Huff, librarian.

OHIO STATE UNIVERSITY

On May 28, the Ohio State Student Branch held a farewell banquet in honor of the Senior Students in mechanical engineering. The following officers for the ensuing term were elected: R. D. Rogers, chairman; C. L. Brown, vice-chairman; W. W. Watson, secretary; K. W. Stinson, treasurer; R. M. Mathews, sergeant-at-arms.

PENNSYLVANIA STATE COLLEGE

At a meeting of the Student Branch of Pennsylvania State College, the following officers were elected for the first semester of the next college year: C. F. Kennedy, president; V. D. Longo, vice-president; W. A. Blume, treasurer; D. E. Hewitt, secretary. Reports were made by the chairmen of the various standing committees and by the treasurer.

Mr. Meyers, a graduate of Stevens Institute of Technology, spoke briefly on the manufacture of iron and steel.

UNIVERSITY OF CINCINNATI

The annual election of officers of the Student Branch of the University of Cincinnati was held in conjunction with a smoker on May 16. The following officers were chosen: J. Dollman, president; R. Rickwood, vice-president; A. J. Langhammer, secretary-treasurer.

Prof. John T. Faig, the honorary chairman of the Branch, gave an address on Utilization of Coal. He discussed the present methods of using the "black diamond," the subsequent nuisances occasioned thereby and remedial measures. Special emphasis was placed upon the efficient utilization of coal by the by-product coke ovens and upon the possibilities in this field.

UNIVERSITY OF MICHIGAN

At a meeting of the University of Michigan Branch on April 23, the following officers were elected to serve until January 1915: R. H. Mills, chairman; C. H. McClellan, recording secretary and treasurer; J. R. Allen, honorary chairman.

On May 18, J. R. McColl gave his paper on Tests of Vacuum Cleaners. Mr. McColl completed his talk with a demonstration in which he showed his method of measuring air pressures in vacuum systems and the effect of different sized orifices upon these pressures.

UNIVERSITY OF MINNESOTA

The regular meeting of the Minnesota Student Branch was held May 7. John Peoples presented a paper on the Efficiency of Rope Driving, which was followed by a discussion.

A. L. Buenger who represented the Student Branch at a meeting of the Executive Committee of the St. Paul-Minneapolis Section gave a report of the meeting.

On May 27, a special meeting was held at which Max Toltz of the St. Paul-Minneapolis Section addressed the Student Branch in regard to being present at the Spring Meeting of the Society.

UNIVERSITY OF MISSOURI

The Student Branch of the University of Missouri held a joint meeting with the Electrical Engineering Society on May 4. Professor Hubbard gave an illustrated talk on the Engineering Societies Building in New York.

At a meeting on May 18, F. H. Heileman gave a talk on

heat treated steel, the benefits derived from heat treatments and the difference between the strength of heat treated and alloy steels.

UNIVERSITY OF NEBRASKA

Engineers week was held during May 4-9 at the University of Nebraska. The events included an address by H. W. Stannard, on Scientific Shop Management, and a smoker at which 250 students were present. All classes were suspended on Friday and in the evening all the engineering laboratories were open to visitors, about 2000 of whom inspected the equipment. The mechanical engineering labora-

tories were the center of attraction, and about 500 souvenirs cast from aluminum in the foundry were given away to the guests. A photograph of these souvenirs is given herewith. The concluding event of the week was a banquet on Saturday evening, at which 350 were present, Bion J. Arnold acting as toastmaster. The speakers included Gov. T. H. Morehead; E. J. Robinson, engineer of valuations of C. B. & Q. R. R.; W. J. Provaznik, city engineer's office, Omaha; George H. Tinker, bridge engineer for N. Y. C. & St. L. R. R.; B. C. Yates, asst. chief engineer, Homestake Mining Co.; H. E. Reagan, president U. S. Equipment Co., Chicago; and Lieut. Col. Herbert Deakyne, Engineering Corps U. S. A.

On May 19, at a meeting of the Student Branch, the following officers were elected: B. F. Merriam, chairman; L. L. Westling, secretary; D. W. Watkins, treasurer; and H. S. McNabb, publicity man.

A special meeting of the Branch was held May 21, to which the Engineers' Club of Lincoln was invited. B. F. Hart of the National Tube Co. of Chicago gave a lecture on the manufacture of steel tubing illustrated by slides and three reels of motion pictures. The pictures showed the processes of manufacture from the mine where the ore was obtained to where the pipe was being shipped. After the lecture, the meeting was open for discussion.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing positions for members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. The published list of "men available" is made up from members of the Society. Notices are not repeated except upon special request. Names and records are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month.

POSITIONS AVAILABLE

523 Salesman for offset printing presses.

524 Salesman who has been a success wanted by Pennsylvania concern; prefer a man who has had experience in sale of boilers or stokers or large power plant apparatus.

526 General Manager who will be willing to invest ten to twenty thousand dollars and thoroughly in sympathy with modern manufacturing methods, wanted for concern manufacturing machinery of every profitable nature. Name confidential. Apply by letter.

601 Company in Middle West have opening in experimental mechanical department for a responsible man experienced in machine design, capable of supervising the work of draftsmen, following it through the shop and developing into practical operation.

604 A large company desires the services of a mechanical engineer who is thoroughly familiar with and capable of passing on locomotive and car design; preferably one who has been connected with a railroad and has had practical as well as theoretical experience. Salary $300 to $350. Apply through Society.

605 Shop superintendent who is familiar with modern shop practice and up-to-date manufacturing methods, for factory located in the east and manufacturing light mechanical and electrical devices. State experience, references and salary expected.

609 Chief engineer to take charge of power plant consisting of a steam and electrical plant. Location, Pennsylvania.

610 College graduate, preferably one who has been out two or three years and acquired a little business experience or acquaintance with business methods, would be employed principally in demonstrating and selling mine rescue apparatus, various styles of reviving apparatus employing artificial respiration and kindred devices; will be expected to make occasional trips to the various coal fields, but would be located at New York office the greater part of the time. Man who has studied elementary chemistry and who is something of a mechanic.

611 Salesman for Eastern states, for thermo-dynamic apparatus as feed water heaters, oil and air coolers, and air heaters; also for condenser line. Location probably in Boston.

612 Instructorship in mechanical engineering department of university in Pennsylvania; prefer man with at least one year's outside experience. Salary $900 to $1000.

613 Vacancy in the mechanical laboratory division of university in Pennsylvania; salary $1400 to $1500. Applicant should have had both outside and teaching experience.

614 Wanted, mechanical engineer thoroughly familiar with shop practice, resourceful in design and manufacture, familiar with the fundamental principles of scientific management, capable of taking charge of a small factory of fifteen men manufacturing mathematical instruments; would be expected to start as draftsman until familiar with the work; only those of good managing ability and push need answer. Give full particulars and references. State salary required to start. Location, Pennsylvania.

617 General manager for sawmill and timber company in North Carolina; does not need to be an engineer but capable of handling large enterprise. Large tract of timber is owned and 50,000 feet or more of timber handled daily. Apply by letter.

620 Successful company manufacturing light machinery desires to add one or more new products and will take over the manufacture and sale of any device that has proven its merit and for which there is a wide market. Name confidential. Apply by letter.

621 Contractor wanted to saw out lumber from large tract in North Carolina. Sales will be arranged. Apply by letter.

MEN AVAILABLE

G-700 Member, thoroughly familiar with the design of gas producers, gas engines from 50 h.p. to 300 h.p. and Corliss engines for all purposes, such as pumping, blowing and hoisting engines, air compressors and power plants, desires position as mechanical engineer or assistant mechanical engineer.

G-701 Student member, technical graduate with gas engine experience, desires position in some gas engine line where advancement may be obtained. At present in charge of care, maintenance and operation of various gasolene engines on large construction job. Would start at $100 per month.

G-702 Member located in Norway desires to act as representative of American firms.

G-703 Mechanical engineer, technical graduate, S.B. and M.M.E., with practical training and executive experience as superintendent with large corporations in steel and automobile business, owing to acute depression of motor truck industry, desires position as superintendent or manager of a plant manufacturing a good line of mechanical product. Location immaterial.

G-704 Member, technical graduate, with 13 years successful teaching experience, will be open for position in September as instructor of mechanical drawing and machine design and related subjects, or as superintendent of shops in an engineering college or university. Would also consider position as director or head of department of a vocational or trades school. Can handle several lines of shop work in both wood and metal.

G-705 Member, age 33, technical graduate, experienced as chief draftsman and as manager of engineering and drafting departments in manufacturing lines desires similar position, or position as mechanical engineer, or assistant to superintendent or manager.

G-706 Pennsylvania State College graduate, degrees B.S. and M.E., age 31, married, with four years shop experience and five years varied engineering teaching experience, desires a position as instructor in the mechanical engineering department of a college. At present teaching.

G-707 Member, age 38, ten years experience in charge of shops and departments, desires position as superintendent or foreman, or practical machinist. Competent to organize; thoroughly familiar with all modern manufacturing methods and systems. Location immaterial.

G-708 Mechanical engineer with technical education, age 30, thorough training in power plant and locomotive testing, desires position as mechanical engineer with large industrial corporation to take charge of power plants, equipment, etc. Past four years connected with architect's office as mechanical engineer in designing power plants, heating, ventilating, electrical and plumbing installations for office buildings, factories and large schools.

G-709 Member, age 32, at present designing special heavy machinery. Has had varied and valuable experience in same and in mill construction; original and practical ideas in design gained by ten years field and office experience. Wishes to connect with company desiring services of capable engineer, superintendent of erection or inspector. Location secondary consideration. Minimum salary $2400.

G-710 Member, age 33, married, at present employed as inspector of mechanical equipment in addition to large power station, desires position as assistant superintendent of power in large generating station, or with large engineering firm designing or erecting power stations. Has had six years experience designing and erecting power houses for industrial plants and railroads.

G-711 Mechanical engineer, technical graduate with 15 years shop and mill experience desires important position as plant engineer, or would consider taking an interest with services in small manufacturing enterprise turning out mechanical goods.

G-712 Technically trained man with shop experience and an extensive record at designing presses, dies and other sheet metal tools, special automatic machines, and machine tools for special purposes, desires employment along these lines.

G-713 Member, technical graduate, with experience in executive work of large corporations, desires position as works manager or superintendent. Wide training and experience in the items which are required of a corporation engineer, such as the design of power plants and machinery, their construction, maintenance and operation, purchasing engineering material, taking executive charge of all consulting work including building construction of all kinds.

G-714 Technical graduate, 37 years of age, 15 years wide experience in teaching manual training, mathematics, drawing and machine design and mechanical engineering subjects, desires a position with broader outlook. Would accept position in a technical high school, industrial school or college as director or head of department.

G-715 M. I. T. graduate, with experience on instructing staff and in efficiency engineering and scientific management in power, manufacturing and auxiliary departments, desires further work along these lines, or permanent executive position with concern desiring energy and ability.

G-716 Associate, age 36, railroad and valuation experience with five large companies; also in mechanical and electrical equipment other than rolling stock and structures. Competent to serve with construction company, or as works or purchasing engineer.

G-717 Junior, ten years practical experience, consulting mechanical engineer with office in Philadelphia, wishes to arrange with a company in that vicinity for part time.

G-718 Graduate M.E., executive, desires position where wide engineering knowledge will be of value. Has served as assistant vice-president and secretary of well known manufacturers of machinery. Duties included sales, advertising, development of new ideas and general office management.

G-719 Member, age 40, mechanical engineer, going to Europe for summer, would assume duties of engineering or commercial nature for firms desiring representative; wide experience in design, manufacture and sales of mechanical and electrical equipments of power and industrial plants, hoisting, conveying and special machinery, motor cars. Fluent knowledge of German, Swedish and Danish, well acquainted with engineering trade conditions and market requirements in Northern Europe. Would consider permanent engagement as foreign representative for reliable concern.

G-720 Mechanical engineer, with ten years experience as draftsman, designer, engineer and superintendent in marine engines, hoisting and conveying machinery, cement machinery and plants, general manufacturing and repair work.

G-721 Junior, age 31, married, foundry assistant superintendent or engineer, with 13 years experience in shop, drawing room and foundry, last four years specializing in foundry efficiency work, installation and operation of equipment. Designer of successful molding machinery, pattern mounting methods, etc.; understands melting and mixing of gray iron, malleable and crucible steel. Capable executive, organizer and investigator.

G-722 Stevens graduate, nine years practical experience on construction and electrical work, also sales experience; wide acquaintance among engineers, architects and builders.

G-723 Junior, age 38, sales engineer, experienced in handling high-grade power transmission and mechanical specialties, desires to represent manufacturer; eastern United States or England preferred.

G-724 Junior, graduate mechanical engineer, age 26, with three years shop and drafting room experience in locomotive construction, desires position with engineering or manufacturing company. Location immaterial.

G-725 Member, mechanical engineer, age 42, married, desires position in which good future can be expected; 14

years experience in drafting, designing, supervising and executive positions, power plant work, heating, ventilating, mill engineering and factory.

G-726 Mechanical engineer, 14 years experience on steam station design and construction, with positions as chief draftsman, resident engineer and superintendent of construction; lately completed the installation of a 7500-kw. turbine condensing plant in Canada. Location immaterial but prefer to connect with New York concern. Can invest some money if desired.

G-727 Junior, age 26, experience in design, construction and operation of steam engines, boilers, refrigerating machinery and power plant accessories; recently employed on hydraulic dredging machinery and pumps.

G-728 Mechanical engineer, age 38, married, 14 years experience in design, construction and operation, wishes position with cement manufacturing company; recently superintendent of a 3000-bbl. plant; salary moderate.

G-729 Graduate University of Cincinnati, age 24, four years experience as machinist, foundry experience, and one year experience in power plant construction and design, would consider position with good chance for advancement, or as instructor in engineering or technical school. Location immaterial.

G-730 Junior, age 27, married, efficiency expert, graduate mechanical engineer, unusual experience in industrial organization methods, desires better opportunity. At present employed.

G-731 Member, technical graduate, at present and for several years past engaged in successful practice as consulting engineer, especially experienced in power requirements and equipment for mining and contracting operations, would consider regular employment with substantial concern; willing to accept smaller prospective compensation in return for greater regularity.

G-732 Student member, technical graduate, desires position in mechanical engineering line, preferably in gas engineering field; can furnish best references.

G-733 Works manager or superintendent, age 36, graduate mechanical engineer with broad experience in factory work; have been especially successful in designing machinery for interchangeable manufacture and organizing men to get best results. At present superintendent of factory employing 800 men, but desires change.

G-734 Graduate mechanical engineer with 18 years experience as draftsman, checker, designer, estimating and selling engineer for various kinds of gridiron and Corliss engines, crank and flywheel pumping engines, air compressors and special machinery, desires position as chief draftsman, selling or estimating engineer or office manager; thoroughly acquainted with modern shop methods of manufacture.

G-735 Associate-Member, mechanical engineer, age 29, nine years experience gas engine design, four years gas traction engine development, extensive carburetor design, desires position as designing engineer or superintendent of experiments; can develop complete motor for use of kerosene or other low-grade fuel.

G-736 Associate-Member four years practical shop and office experience in all departments of well known company, desires to locate permanently with a first class concern as sales manager or factory superintendent.

G-737 Commercial engineer, M.E. 1904, Associate-Member, knowledge of five languages, invites correspondence for position where tact with engineering skill will be appreciated.

G-738 Energetic young man, age 21, graduate M.E. 1914, unmarried, desires to enter commercial field with manufacturing concern; have had some business experience; location immaterial.

PERIODICALS WANTED

Following is a list of periodicals which the Library of the Engineering Societies desires to obtain in order to complete its list of reference sets. Anyone having any of the missing numbers will confer a favor by communicating with the librarian, W. P. Cutter, 29 West 39th Street, New York.

Acetylene Journal. 1-13, 1899-1912.
Acetylen in Wissenschaft und Industrie. 1-12, 1898-1909.
Acetylene. 1-5, 1903-1908.
Aëronautical Journal. 1-12, 1897-1908.
Allgemeine Automobil Zeitung. 1-9, 1900-1908 (Berlin).
Allgemeine Bauzeitung. 1-date, 1836-date.
American Lumberman. 1-date, 1899-date.
Annalen der Chemie (Liebig's). 1-364, 1832-1909.
Annales des Mines Belgique. 1-8, 1896-1903.
Annales des Ponts et Chaussée. Memoires et documents. Ser. 1-5; Ser. 6, vols. 1-16, 19-end of ser.; Ser. 7; Ser. 8, vols. 1-30, 36.
——— Lois decrets, etc. Ser. 1-5; Ser. 6, vols. 1-8, 10-end of ser.; Ser. 7; Ser. 8, vols. 1-7, 8 pt. 1.
——— Personnel. All before 1889, and any issued to date.
Annales des Travaux Publics de Belgique. 1-date, 1843-date.
Archiv für Eisenbahnwesen. 1-30, 1878-1907.
Autogene Metallbearbeitung. 1-date, 1908-date.
Berg und Hüttenmannische Zeitung. Vols. 1-21; 44, no. 36; 49, no. 14, 45, 51; 50, nos. 8, 47; 51, no. 19; 52, nos. 39, 41; 42, 44-52; 54, nos. 2, 3, 4, 25, 26, 29, 30, 32; 55, no. 10.
Beton und Eisen. 1-2, 1902-1903.
Braunkohle. 1-7, 1902-1908.
Brick. 1-42, 1894-1913.
Cement and Engineering News. 1-21, 22, no. 2, 1896-1909, 1910.
Centralblatt der Bauverwaltung. 1-33, 1881-1913.
Chemical Engineer. 1-4, 1904-1906.
Chemical Society of London. Journal. 1-26, 1849-1873.
Chemiker Zeitung. 1-10, 12, 1877-1886, 1888.
Chemische Industrie. 1-date, 1878-date.
Chemisches Centralblatt. 1-date, 1830-date.
Ciment (Paris). 1-date, 1896-date.
Connecticut Society of Civil Engineers. Papers. 1-25, 27, 1894-1909.
Contractor (Chicago). 1-date, 1898-date.
Deutsche chemische Gesellschaft, Berichte. 1-6, 1868-1873.
Eisen Zeitung. 1-24, 1880-1903.
Electrician. Ser. 1, vol. 10 to end of series, 1886-1890.
Elektrische und Maschinelle Betriebe (Leipzig). 1-date, 1898-date.
Elektrochemische Zeitschrift. 1-8, 1894-1901.
Elektrophysikalische Rundschau. 1-3, 1910-1912.
Elektrotechnische Nachrichten. 1-date, 1905-date.
Feuer und Wasser. 1-date, 1894-date.
Fonderie Moderne. 1-4, 1908-1911.
Gas World. 1-58, 1884-1913.
Gazetta chimica Italiana. 1-date, 1871-date.
Geographical Journal. 33-date, 1908-date.
Geological Magazine. 4 to new ser. decade, 5, vol. 5, 1867-1908.
Geologisches Zentralblatt. 1-11, 1898-1908.
Gesundheits Ingenieur. 1-31, 1878-1908.
Glückauf. 1-31; 36, no. 27; 38, nos. 2, 7, 1865-1902.
Gummi Zeitung. 1-21, 1888-1906.
Haeder's Zeitschrift für Maschinenbau. 1-20, 1893-1912.
Helios. 1-date, 1895-date.
Houille Blanche. 1-10, 1902-1911.
Ingenieur (The Hague). 1-24, 1886-1902.
Institute of Marine Engineers. 1-20, 1889-1909.
Institution of Engineers and Shipbuilders in Scotland. 1, 8, 1857, 1865.

Iron Age. 1-23, 1855-1878.
Jern Kontortes Annaler. 2, 4, 13, 16, 17, 19, 20. New Ser. 1, pts. 1-2; 3; 5-11; 12, pt. 5-end of vol.; 14-15; 28, pts. 1-3, 6-end of vol.; 29, pts. 1-2, 4-5; 30, pt. 2; 31, pts. 2-5; 54, pt. 1; 63, pts. 3-4, 1818-1908.
——— Bihang. All before 1828, 1829-1836, 1838-1867, 1869-1899.
——— Register. 1817-1890.
Journal für Gasbeleuchtung. 1-51, 1858-1908.
Journal für Praktische chemie. 1-date, 1828-date.
Journal of Gas Lighting. 1-22, 51-52, 56, 62-63, 93, 96, 99-108, 1850-1909.
Koninklijk Instituut von Ingenieurs (Hague). Tijdschrift. 1870-1903, 1906.
Marine Engineer and Naval Architect. 1-25, 1879-1903.
Metallrohren Industrie. 1-date, 1907-date.
Metallurgie (Paris). 1-32, 37, 40, 1868-1909.
Mining and Scientific Press. 1-9, 11-19, 24-33, 1860-1876.
Mining Journal (London). 1-47, 59, 1835,1877, 1889.
Mittheilunges aus Justus Perthes Geographischer Anstalt. 43-date, 1897-date.
Motorwagen (Berlin). 1-13, 1898-1908.
Municipal Engineering. 1-21, 24-31, 1890-1901, 1903-1906.
Nature (Paris). 1-date, 1873-date.
Neueste Erfindungen und Erfahrungen. 1-date, 1874-date.
Oesterreichische Zeitschrift für Berg und Hüttenwesen. 1-26, 1853-1878.
Omnia. 1-7, 1906-1912.
Petroleum. 1-3, 1905-1907.
Petroleum Review, London. 1-25, 1889-1911.
Petroleum World. 1-8, 1903-1910.
Prometheus. 1-19, 1879-1908.
Revista tecnica delle Ferrovie Italiana. 1-date, 1912-date.
Revue de la Soudure Autogène. 1-date, 1909-date.
Revue Générale des Sciences pure et Appliquée. 1-10, 1890-1899.
Schiffbau. 1-9, 1899-1908.
Schweizerische Bauzeitung. 1-56, 1874-1910.
Société Belge des Electriciens. 1-3, 5, 8-9, 11-20, 1884-1903.
Société Industrielle de Mulhouse. 1-71, 1828-1901.
Sozial Technik. 1-6, 1902-1907.
Sprechsaal. 1-41, 1868-1908.
Teknisk Tidsskrift. 1-25, 1877-1901. (Köpenhagen.)
Telefunkenzeitung. 1-date, 1911-date.
Tonindustrie Zeitung. 1-31, 1877-1907.
Verein zur Beförderung des Gewerbefleisses. Verhandlungen. 1-88, 1822-1909.
Water and Water Engineering. 1-date, 1899-date.
Zeitschrift des Verbandes deutscher Schiffsingenieure. 1-date, 1911-date.
Zeitschrift für Architektur u. Ingenieurwesen (Architekten u. Ing. Verein zu Hannover). 1-48, 1855-1902.
Zeitschrift für Bauwesen. 1-date, 1851-date.
Zeitschrift für Beleuchtungswesen. 1-7, 1895-1901.
Zeitschrift für Dampfkessel und Maschinenbetrieb. 1-36, 1878-1913.
Zeitschrift für Elektrotechnik und Maschinenbau. 1-5, 1898-1902.
Zeitschrift für Heizung, Lüftung und Beleuchtung. 1-12, 1896-1908.
Zeitschrift für Kleinbahnen. 1, 3-8, 1894, 1896-1901.
Zeitschrift für komprimierte und flüssige Gase. 1-date, 1897-date.
Zeitschrift für Physikalische chemie. 1-date, 1887-date.
Zeitschrift für Sauer und Stickstoffindustrie. 1-date, 1908-date.
Zeitschrift für Transportwesen. 1-28, 1884-1907.
Zeitschrift für d. Gesamte Kälteindustrie. 1-15, 1894-1908.
Zeitschrift für das ges. Schiess u. Sprengstoffwesen. 1-date, 1906-date.
Zeitschrift für d. Gesamte Turbinenwesen. 1-3, 1904-1906.
Zement und Beton. 1-date, 1902-date.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary Am. Soc. M. E.

Agricultural and Mechanical College of Texas. Pictorial Number, March 1914. Gift of the college.

American Labor Legislation Review (Unemployment Number). vol. 4, no. 2, May 1914. *New York, 1914.*

American Machinist Gear Book, Chas. H. Logue. *New York, 1911.*

American Wood Preservers' Association. Proceedings of 10th Annual Meeting, 1914. *Baltimore.* Gift of Association.

Asphalts, their Sources and Utilizations, 1914 road edition, T. H. Boorman. *New York, 1914.* Gift of author.

The Autocar Imperial Year Book 1914. *London, 1914.*

Automobile Dictionary, Sigmund Krausz. *London, 1907.*

Automobile Engineer Year Book for 1914. *London, 1914.*

Aviation, an Introduction to the Elements of Flight, A. E. Berriman. *London, 1913.*

Baumaterialienkunde. vol. 7. *Stuttgart, 1902.*

Carnegie Foundation for the Advancement of Teaching. Annual Report, 8th, 1913. *New York, 1913.* Gift of Carnegie Foundation.

Centrifugal Fans, J. H. Kinealy. *New York-London, 1907.*

Circolo Matematico di Palermo. Adunanza solenne del 14 Aprile 1914. XX Anniversario della Fondazione. *Palermo, 1914.* Gift of Circolo Matematico di Palermo.

Communications presentées devant le Congrès International des Méthodes d'Essai des Matériaux de Construction. vols. 1-2. *Paris, 1901.*

Conquest of the Air, Alphonse Berget. *New York, 1911.*

Construction of Cranes and Other Lifting Machinery, E. C. R. Marks. ed. 3. *London, 1904.* Gift of Hunt Memorial Fund.

Control of Water as applied to Irrigation, Power and Town Water Supply Purposes, P. A. M. Parker. *New York, 1913.*

Cost Accounting on Construction Work, with a description of the System used by the Aberthaw Construction Company, Leslie H. Allen. *Boston, 1914.* Gift of author.

Croton Water Supply: its quality and purification, Geo. W. Fuller. Gift of author.

The Development of our Foreign Trade. Address of Mr. John Hays Hammond at the Meeting of the American Association for the Advancement of Science, Atlanta, Ga., December 30, 1913. Gift of C. W. Rice.

Einführung in die Aeronautik, Adolf Lippmann. vol. 1. *Leipzig, 1911.*

Eingriffverhältnisse der Schneckengetriebe, Ad. Ernst. *Berlin, 1904.*

Elementary Treatment of the Theory of Spinning Tops and Gyroscopic Motion, Harold Crabtree. *London, 1909.*

Engineering Contracts. Representations of Fact in Specifications—General Cautionary Clauses. Decision of the Supreme Court of the United States. *Washington.*

Evaporation in the Cane and the Beet Sugar Factory, Edward Koppeschaar. *London, 1914.*

Forscherarbeiten auf dem Gebiete des Eisenbetons, pt. 24. *Berlin, 1914.*

Foundations and Machinery Fixing, F. H. Davies. *London, 1912.*

Foundry Machinery, E. Treiber. Translated from the German by Chas. Salter. *London, 1913.*

General Society of Mechanics and Tradesmen of the City of New York, Historical sketch and government, 1785-1914. *New York.* Gift of General Society of Mechanics and Tradesmen.

Das Generatorgas seine erzeugung und verwendung, Carl Kietaibl. *Wien-Leipzig, 1910.*

Heating: The Theory and Practice of Heating and Ventilation, A. H. Barker. *London, 1912; New York, 1913.*

Heating and Ventilation, Chas. L. Hubbard. *Chicago, 1909.*

Heizung und Lüft von Gebäuden, Anton Gramberg. *Berlin, 1909.*

Hydraulic Machinery, R. G. Blaine. ed. 3. *London, 1913.*

Illustrirte Zeitung, Descriptive Number of the City of Düsseldorf. *March 26, 1914.* Gift of Brentano.

Leitfaden der Luftschiffahrt und Flugtechnik, Raimund Nimführ. ed. 2. *Wien, 1910.*

Library Company of Philadelphia. Bulletin no. 72, April, 1914. *Philadelphia, 1914.*

Lowell Textile School. Bulletin 1914-1915. *Lowell, 1914.* Gift of Lowell Textile School.

Die Luftschiffahrt der Gegenwart, Hermann Hoernes. *Wien, 1903.*

Marine Steam Engine, Richard Sennett and Henry J. Oram. ed. 11. *New York-London, 1913.*

Der Maschinenbau, Eduard Breslauer. 3 Vols. *Leipzig, 1906.*

National Commercial Gas Association. Proceedings of 9th Annual Convention, 1913. *New York, 1913.* Gift of the Association.

Den Norske Ingenior-og Arkitektforenings. Honorarnorm for Ingeniorarbeider. *Kristiania, 1906.*

Nouvelles machines frigorifiques basées sur l'Emploi de phénomènes Physico-chimiques, Raoul Pictet. *Genève, 1885.*

Over-Type Superheated Steam Engines, W. J. Marshall. *London, 1913.*

Practical Treatise for Boilermakers, I. J. and H. Haddon. *Cardiff, 1913.*

Present Position of the Diesel Engine Chiefly in Marine Propulsion, George Carels. *Newcastle-upon-Tyne, 1913.* Gift of W. R. Haynie.

Should the Sherman Anti-Trust Law be Amended? Address of Mr. John Hays Hammond at the 14th Annual Meeting of The National Civic Federation held at Hotel Astor, New York, December 12, 1913. Gift of C. W. Rice.

Société Suisse des Ingénieurs et des Architectes. Annuaire 1913 et Liste des Membres. *Zurich, 1914.* Gift of the Society.

Statement of Bion J. Arnold, with reference to the report dated April 28, 1914, of Narrow, Wade, Guthrie & Co., made to John E. Traeger, City Comptroller, City of Chicago, upon the accounts of the Chicago City Railway Company. *Chicago, 1914.* Gift of C. W. Rice.

Steam Boilers and Boiler Accessories, W. Inchley. *New York, 1912.*

Sub-Surface Structures in New York. Read before American Society of Engineering and Architectural Contractors, May 12, 1914. Gift of T. H. Boorman.

Technische Messungen bei Maschinenuntersuchungen und im Betriebe, A. Gramberg. ed. 2. *Berlin, 1910.*

Testing of Steam Boilers, A. C. Lomshakof (in Russian). *St. Petersburg, 1897.*

Text Book on Motor Car Engineering, A. G. Clark. vol. 1. *London, 1911.*

Aus Theorie und Praxis des Riementriebes mit besonderer Berüchsichtigung der "Riementriebe Boesner" D.R.P., Fritz Adolf Boesner. *Berlin, A. Seydel, 1914.*

A treatise on belt drive written by the inventor, in which he discusses the theory of belts as applied to his invention. Many interesting tests are given.

Throop Polytechnic Institute. Bulletin, vol. 20, no. 52; vol. 21, no. 57; vol. 22, no. 61; vol. 23, no. 62. *Pasadena, 1911-1914.* Gift of the institute.

Toothed Gearing, Geo. T. White. *London, 1912.*

Toothed Gearing; a Practical Handbook for Offices and Workshops, Joseph Horner. ed. 2. *London, 1904.*

Treatise on Thermodynamics, Max Planck. Translated by Alex. Ogg. *London-New York, 1903.*

Vorlesungen über Technische Mechanik. Aug. Föppl. vol. 2, ed. 3. *Leipzig, 1912.*

Water Power. Fifth National Conservation Congress, Washington, D. C., November 18-20, 1913.

Die Werkzeugmaschinen, Hermann Fischer. 2 vols. *Berlin, 1905.*

EXCHANGES

American Ephemeris and Nautical Almanac, 1916. *Washington, 1914.*

American Society of Heating and Ventilating Engineers. Transactions, vol. 17. *New York, 1914.*

Deutschen Museums. Verwaltungs Vericht über das zehnte Geschaftsjahr 1912-1913. *München, 1913.*

U. S. Naval Observatory. Publications (Second series). vol. 8. *Washington, 1914.*

UNITED ENGINEERING SOCIETY

Bibliographie der Deutschen Zeitschriften-Literatur, F. Dietrich. vol. 33, 1913. *Leipzig, 1914.*

Deutsches Rettungswesen. *Berlin, 1913.*

Dictionnaire Autotechnique en quatre Langues, R. Schmidt. vols. 2, 3, 4. *Leipzig, 1906-1908.*

Engineers' Club of Boston. By-laws, Officers and List of Members, 1914. *Boston, 1914.* Gift of Engineers' Club of Boston.

Guide to the Current Periodicals and Serials of the United States and Canada. By H. O. Severance. ed. 3, 1914. *Ann Arbor, 1914.*

New International Encyclopaedia. ed. 2. vols 1-2. *New York, 1914.*

New York Times Index. Jan.-March, 1914. *New York, 1914.*

Spanish-English Dictionary of Mining Terms, F. Lucas. *London, 1905.*

Die Technik der Vorzeit, der Geschichtlichen zeit und der Naturvölke, F. M. Feldhaus. *Leipzig, 1914.*

Technisches Wörterbuch für Werkzeugmaschinen und Maschinenwerkzeuge, Chr. Elsner and Hugo Kriegeskotte. *Berlin, 1910.*

Thermal Reactions in Carbureting Water Gas, W. F. Rittman. *New York, 1914.* Gift of author.

Who's Who in New York (City and State), 1914. *New York, 1914.*

Wisconsin Industrial Commission. Proposed Building Code. *Madison.* Gift of commission.

Das Zelluloid, C. Piest, E. Stich and W. Vieweg. *Halle, 1913.*

TRADE CATALOGUES

Babcock & Wilcox Co., *New York, N. Y.* Forged steel water tube marine boilers. ed. 2. 1914.

Koehring Machine Co., *Milwaukee, Wis.* Koehring mixer. May, 1914.

New York Air Brake Co., *New York, N. Y.* Cat. air brake apparatus, September 1913.

Société Anonyme des Pieux Armés Frankignoul. *Liége, Belgium.* Spécialité de Fondations en terrains compressibles aquifères, de remblais ou miniers (Systéme Breveté), 125 pp.

OFFICERS AND COUNCIL

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Secretary

CALVIN W. RICE

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Note—Numbers in parentheses indicate number of years the member has yet to serve

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Increase of Membership

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International Engineering Congress 1915

The President, The Secretary, W. F. Durand, E. C. Jones, T. W. Ransom, C. R. Weymouth

National Museum

E. D. Meier, *Chairman;* G. F. Kunz, George Mesta, H. G. Reist, Ambrose Swasey

Changes in the Patent Laws of United States

W. H. Blauvelt, C. C. Thomas, Edward Weston, W. E. Winship, B. F. Wood

Pipe Thread Gages

E. D. Meier, *Chairman;* George M. Bond, A. M. Houser, J. C. Meloon, C. A. Olson, P. C. Patterson, H. G. Stott

International Standard for Pipe Threads

E. M. Herr, *Chairman;* W. J. Baldwin, G. M. Bond, S. G. Flagg, Jr.—L. V. Benet, *Paris Representative*

Power Tests

G. H. Barrus, *Chairman;* E. T. Adams, L. P. Breckenridge, D. S. Jacobus, William Kent, E. F. Miller, Arthur West, A. C. Wood

Refrigeration

D. S. Jacobus, *Chairman;* P. De C. Ball, E. F. Miller, A. P. Trautwein, G. T. Voorhees

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R. D. Mershon

Research Committee. Sub-Committee on Safety Valves.

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Research Committee. Sub-Committee on Steam

R. H. Rice, *Chairman;* C. J. Bacon, E. J. Berg, W. D. Ennis, L. S. Marks, J. F. M. Patitz

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J. E. Sweet, *Chairman;* F. R. Hutton, *Secretary;* H. H. Suplee

Standard Cross-Section Symbols

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Standardization of Filters

G. W. Fuller, *Chairman;* J. C. Boyd, P. N. Engel, J. C. W. Greth, Wm. Schwanhausser

Steam Boilers and Other Pressure Vessels and for Care of Same in Service. Committee to Formulate Standard Specifications for the Construction of

J. A. Stevens, *Chairman;* W. H. Boehm, R. C. Carpenter, Richard Hammond, C. L. Huston, E. D. Meier, E. F. Miller

Student Branches

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Tellers of Election

J. P. Ilsley, *Chairman;* R. T. Kent, R. J. S. Pigott

Tolerances in Screw Thread Fits

L. D. Burlingame, *Chairman;* Ellwood Burdsall, F. G. Coburn, F. H. Colvin, A. A. Fuller, James Hartness, H. M. Leland, W. R. Porter, F. O. Wells, Walter F. Worthington

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ron and Steel
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Paul P. Bird, *Chairman;* C. W. Naylor, *Secretary;* C. R. Birdsey, W. B. Jackson, A. W. Moseley

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J. B. Stanwood, *Chairman;* J. T. Faig, *Secretary;* W. G. Franz, G. W. Galbraith

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Minnesota
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New York
R. V. Wright, *Chairman;* Edward Van Winkle, *Treasurer;* H. R. Cobleigh, *Secretary;* J. J. Swan, J. P. Neff

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H. E. Ehlers, *Chairman;* W. R. Jones, *Secretary;* Geo. R. Henderson, Hugo Bilgram, R. H. Fernald, D. R. Yarnall

San Francisco
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St. Louis
F. E. Bausch, *Chairman;* E. L. Ohle, *Secretary;* H. Wade Hibbard, John Hunter, L. C. Nordmeyer

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Council of Amer. Assn. Adv. Science
A. C. Humphreys, W. B. Jackson

Engineering Education
A. C. Humphreys, F. W. Taylor

John Fritz Medal
J. A. Brashear (1), F. R. Hutton (2), J. R. Freeman (3), Ambrose Swasey (4)

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C. W. Baker

Trustees United Engineering Society
Fred J. Miller (1), Jesse M. Smith (2), Alex. C. Humphreys (3)

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Gas Power Committee on Meetings
Wm. T. Magruder, *Chairman;* W. H. Blauvelt, E. D. Dreyfus, A. H. Goldingham, Nisbet Latta, H. B. MacFarland

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Providence Association of Mechanical Engineers

W. H. Paine, *President;* Arthur H. Annan, *Vice-President;* J. Ansel Brooks, *Secretary;* A. H. Whatley, *Treasurer*

Note—Numbers in parentheses indicate number of years the member has yet to serve

OFFICERS OF THE STUDENT BRANCHES

INSTITUTION	DATE AUTHORIZED BY COUNCIL	HONORARY CHAIRMAN	CHAIRMAN	CORRESPONDING SECRETARY
Armour Inst. of Tech.	Mar 9, 1909	G. F. Gebhardt	F. L. Brewer, Jr.	J. A. Agee Armour Inst. of Tech., Chicago, Ill.
Carnegie Inst. of Tech.	Oct 14, 1913	W. Trinks	J. B. Patterson	W. M. Sheldon 5137 Woodlawn Ave., Pittsburgh, Pa.
Case School of Applied Science	Feb 14, 1913	F. H. Vose	H. C. Mummert	J. B. Whitacre Case School of Applied Science, Cleveland, O.
Columbia Univ.	Nov 9, 1909	Chas. E. Lucke	H. F. Allen	A. S. Henry 333 Central Park W., New York, N. Y.
Cornell Univ.	Dec 4, 1908	R. C. Carpenter	J. G. Miller	D. S. Wegg, Jr. 16 E. Ontario St., Chicago, Ill.
Kansas State Agri. College	Feb 13, 1914	A. A. Potter	V. Whiteside	J. I. Michaels P. O. Box 125, Manhattan, Kan.
Lehigh Univ.	June 2, 1911	P. B. de Schweinitz	A. V. Bodine	H. A. Brown Lehigh Univ., South Bethlehem, Pa.
Leland Stanford Jr. Univ.	Mar 9, 1909	W. F. Durand	J. A. Gibb	C. L. Addleman 219 Ramona St., Palo Alto, Cal.
Mass. Inst. of Tech.	Nov 9, 1909	E. F. Miller	F. G. Purinton	H. E. Morse Box 233, East Bridgewater, Mass.
New York Univ.	Nov 9, 1909	C. E. Houghton		
Ohio State Univ.	Jan 10, 1911	Wm. T. Magruder	R. D. Rogers	W. W. Watson 153 W. 8th Ave., Columbus, O.
Penn. State College	Nov 9, 1909	J. P. Jackson	C. F. Kennedy	D. E. Hewitt 412 Main Bldg., State College, Pa.
Poly. Inst. of Brooklyn	Mar 9, 1909	W. D. Ennis	M. Van Valkenburgh	Samuel Kobre Poly. Inst. of Brooklyn, Brooklyn, N. Y.
Purdue Univ.	Mar 9, 1909	G. A. Young	S. A. Peck	T. S. Tulien 216 Fillmore St., Topeka, Kan.
Rensselaer Poly. Inst.	Dec 9, 1910	A. M. Greene, Jr.	F. E. McMullen	R. L. Manier 90 Walnut St., Binghamton, N. Y.
State Univ. of Iowa	Apr 11, 1913	R. S. Wilbur	L. A. White	H. C. Doane Newton, Ia.
State Univ. of Kentucky	Jan 10, 1911	F. P. Anderson	H. G. Strong	R. T. Thornton R. R. 1., Lexington, Ky.
Stevens Inst. of Tech.	Dec 4, 1908	Alex. C. Humphreys	L. F. Bayer	C. H. Colvin 56 N. Maple Ave., East Orange, N. J.
Syracuse Univ.	Dec 3, 1911	W. E. Ninde	G. T. Parsons	W. J. Campbell 303 Waverly Ave., Syracuse, N. Y.
Univ. of Arkansas	Apr 12, 1910	B. N. Wilson	M. McGill	C. Bethel Univ. of Ark., Fayetteville, Ark.
Univ. of California	Feb 13, 1912	Joseph N. LeConte	A. C. Moorhead	H. L. McLean Univ. of Cal., Berkeley, Cal.
Univ. of Cincinnati	Nov 9, 1909	J. T. Faig	J. Dollman	A. J. Langhammer 713 Crescent Ave., Covington, Ky.
Univ. of Colorado	Apr 10, 1914	P. S. Rattle	L. J. Brady	S. S. Cooke 1290 Race St., Denver, Colo.
Univ. of Illinois	Nov 9, 1909	W. F. M. Goss	C. R. Velzy	E. F. Gehrig Univ. of Illinois, Urbana, Ill.
Univ. of Kansas	Mar 9, 1909	F. H. Sibley	L. C. Angevine	H. L. Newby 1501 Rhode Island St., Lawrence, Kan.
Univ. of Maine	Feb 8, 1910	Arthur C. Jewett	E. E. Fowler	A. B. Hayes S. A. E. House, Orono, Me.
Univ. of Michigan	Apr 10, 1914	John R. Allen	R. H. Mills	C. H. McClellan 928 Oakland Ave., Ann Arbor, Mich.
Univ. of Minnesota	May 12, 1913	J. J. Flather	A. Buenger	J. L. Hartney 1724 Fourth St., S. E., Minneapolis, Minn.
Univ. of Missouri	Dec 7, 1909	H. Wade Hibbard	F. A. Heileman	F. H. Frauens 212 E. 35th St., Kansas City, Mo.
Univ. of Nebraska	Dec 7, 1909	J. D. Hoffman	A. A. Luebs	G. W. Nigh c/o G. W. Nigh, Sr., Havelock, Neb.
Univ. of Wisconsin	Nov 9, 1909	H. J. Thorkelson	M. A. Cook	R. E. Maurer c/o The Utah Gas & Coke Co., Salt Lake City, Utah.
Washington Univ.	Mar 10, 1911	E. L. Ohle	A. O. Schleiffarth	J. A. Watkins, Jr. 5803 Michigan Ave., St. Louis, Mo.
Yale Univ.	Oct 11, 1910	L. P. Breckenridge	L. F. Harder	M. C. Corbett 288 Orchard St., New Haven, Conn.

PERSONAL NOTES

Charles L. Pillsbury has recently been engaged in two appraisal undertakings with Prof. E. W. Bemis of Chicago, with whom Mr. Pillsbury worked on the Minneapolis gas appraisal, one of these at Washington, where Mr. Pillsbury is acting as chief engineer in charge of the appraisal of all public utilities of the District of Columbia, and the other in Detroit, where the street railway properties are being appraised.

J. R. Bibbins of Chicago has been engaged by the law department of the City of Pittsburgh in an advisory capacity in connection with proceedings for the improvement of local transportation conditions in that city. This work has the support of the city administration and through coöperative study of the various phases of the problem with the Railways Company an attempt will be made for an operative service standard, for scientific re-routing in the terminal district, and for progressive rehabilitation of the property until adequate physical condition is reached. The matter will then be referred to the Public Service Commission.

Thomas H. Mirkil, Jr., has resigned as vice-president and general manager of the Poole Engineering & Machine Company, Baltimore, and is now resident manager of the Treadwell Engineering Company of Easton, Pa., with an office at 1011 Chestnut Street, Philadelphia.

Chas. S. Mott, president of the Weston Mott Company, Flint, Mich., and ex-mayor of that city, was recently tendered a dinner in celebration of his return from a trip abroad, by men who had been intimately associated with Mr. Mott in the development of local industrial enterprises. The speakers called attention to Mr. Mott's efforts in the direction of city betterment and his insistence upon the application of business principles in municipal affairs.

Ralph W. Deacon has been appointed superintendent of the U. S. Metals Refining Company, Chrome, N. J. He was formerly associated with the British America Nickel Corporation, Ltd., Nickelton, Canada, as metallurgical superintendent.

William H. Smead has severed his relations with The Samuel Austin & Son Company, Cleveland, Ohio, as manager of the heating and equipment department, and has opened an engineering office in Cleveland, Ohio, making a specialty of forced hot water heating systems and power house plants.

David C. Fenner has become affiliated with the General Vehicle Company, Inc., New York. He was until recently in the employ of the International Motor Company, New York.

Jay W. Skinkle, who has been associated with the Western Electric Company, Chicago, Ill., for the past 15 years, during the last six of which he has been in charge of the manufacturing methods department, has been transferred to the European organization of the company and sails for London on August 1. Mr. Skinkle's work will be on the manufacturing staff with headquarters at the company's factory at North Woolwich, London, and his duties will require frequent visits to the manufacturing plants of the Western Electric Company, of which there are several in the principal cities of Europe.

Walter N. Polakov, formerly consulting engineer with Day & Zimmermann of Philadelphia, Pa., is now associated with The New York, New Haven & Hartford Railroad Company, as superintendent of power.

Frederick O. Ball has resigned as general manager of the American Engine and Electric Company of Bound Brook, N. J., and will engage in the manufacture and sale of carburetors with his father, Frank H. Ball, who retired from the engine business last year. The carburetor business will be conducted under the firm name of Ball & Ball, with headquarters in Detroit, Mich.

Dwight O. Barrett has accepted the position of superintendent of the Charles City Engine Company, Charles City, Ia. He was formerly affiliated with the Heer Engine Company, Portsmouth, Ia., in the same capacity.

Gerald E. Terwilliger has terminated his association with Messrs. Davis, Donohue, Thompson & Deitz, and will continue the practice of patent trade-mark and copyright law at 50 Church St., New York, in association with Clifford E. Dunn.

Harry J. Klotz has resigned his position as assistant in mechanical engineering at Rensselaer Polytechnic Institute, Troy, N. Y., and has accepted a position in the operating engineering department of the Illinois Traction System, Peoria, Ill.

William Fowden, recently superintendent of the U. S. Portland Cement Company, Concrete, Colo., has become connected with the Dewey Portland Cement Company, Dewey, Okla., in the same capacity.

Allen V. Moyer has accepted the position of mechanical engineer with the George T. Ladd Company, Pittsburgh, Pa. He was formerly associated with the Heine Safety Boiler Company of Phoenixville, Pa.

N. N. Williams has become a Junior Member of the firm of E. T. Archer & Company of Kansas City, Mo. He was until recently affiliated with the Harrisburg Light & Power Company, Harrisburg, Pa., as mechanical engineer.

James U. Norris, formerly connected with the Rockefeller Institute for Medical Research, New York, as assistant manager, has accepted the position of superintendent of the New York Polyclinic Medical School and Hospital, New York.

EMPLOYMENT BULLETIN

Note: In sending applications stamps should be enclosed for forwarding.

The Secretary considers it a special obligation and pleasant duty to be the medium of securing positions for members, and is pleased to receive requests both for positions and for men. The published notices of "men available" are made up from members of the Society. Notices are not repeated except upon special request. Names and records are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month.

POSITIONS AVAILABLE

608 Engineer or draftsman with wide experience in the construction and design of steel cars for elevated and underground railroads, wanted for employment in car factory in Germany; traveling expenses paid, and only slight knowledge of German language required. State salary expected.

611 Salesman for Eastern States, for thermo-dynamic apparatus as full line of condensers, recooling apparatus, feed water heaters, air and oil coolers, air heaters, air filters and washers for generators. Location Boston.

701 Young engineer, technical training with experience in devising methods of reducing costs in a machine shop building medium and heavy machinery. Knowledge of pumping machinery desirable, but not necessary. Must be tactful and have ability to exhaust the possibilities of cost reduction with present equipment before suggesting purchase of new. Apply by letter.

703 Foreman, between 33 and 42 years of age, for machine shop, employing normally about sixty men, and manufacturing heavy special machine tools for use in works, also manufactured products entering into the sales product. Salary will be fixed according to ability, experience and possible competency for other position in the organization of the company. Apply by letter. State age, detail of schooling and previous experience.

704 Engineer salesman for Chicago territory, for thermodynamic apparatus, such as full line of condensers, recool-

ing apparatus, feed water heaters, oil and air coolers, air heaters, air filters and turbo-generators.

705 Young man of analytic turn of mind and with gift of "trading marbles" wanted in sales department for paper mill lines of middle west concern. Apply by letter.

706 Cost man to have actual charge of time and as assistant to superintendent of concern in middle west, manufacturing power pumps and paper mill machinery. Apply by letter.

707 Man to take charge of designing and engineering work of railroad motor cars and some kindred lines. Would prefer one who has had some experience in railroad work. Location Michigan.

709 Representation wanted, notably in Philadelphia, Pittsburg, St. Louis, Kansas City and Omaha, by mechanical engineers who are established with their own offices and will be able to take up the handling of the "Productograph."

713 Graduate engineer to take responsible charge in the field of a modern steam shovel plant, consisting of shovels, locomotives, cars, etc., of company operating in anthracite coal region. Applicant must have some experience with steam shovels, familiarity with their mechanism and capabilities. Present salary $200 per month.

MEN AVAILABLE

H-800 Member, technical graduate, desires position as chief draftsman, mechanical engineer, or designer of steam pumps, simplex or duplex; several years experience designing, testing and erecting. At present employed.

H-801 Superintendent capable of handling large machine shops, foundries and manufacturing plants; wide experience on high grade work, good executive, has organized and completely equipped large modern shops.

H-802 Mechanical engineer, Junior, thoroughly familiar with machine tools and specialties, bridge, structural and pipe contract work desires commission agencies. Located on the Pacific coast.

H-803 Graduate mechanical engineer, two years outside experience of varied nature, desires position as instructor; prefers laboratory or steam power plant work. Can furnish best references.

H-804 Technical graduate in mechanical and electrical engineering, six years shop experience and four years as traveling salesman, desires to represent a first class company in Philadelphia or vicinity as manufacturers' agent.

H-805 Member, technical graduate, age 35, wide experience in design and application of steam and compressed air machinery, at present engaged in successful independent consulting practice, would consider regular employment with a view to permanent association with an aggressive and responsible concern; would qualify as engineer in purchasing or plant departments of industrial or mining properties.

H-806 Member, graduate M.E., over 25 years experience in his line, owing to slightly defective hearing, wishes to change to a field of work in which this will not be a hindrance to efficiency and advancement, as research, experiment, testing, inventions, patents, designs, development work, examinations, investigations, reports, office or field, or with consulting engineer, company or corporation.

H-807 Junior, wide experience in steam turbine power plants, electric railway and lighting properties, eliminating operating difficulties, reducing costs, securing new business in positions of chief and electrical engineer, desires position as salesman of electrical or steam equipment. Prefers position in Middle States or Middle West; no objection to traveling.

H-808 Purdue University graduate, '03, who has for several years specialized on research and development work, desires position with firm requiring investigation of engines, machinery or materials of construction.

H-809 Member, technical graduate, age 33, experienced as chief draftsman and as manager of engineering and drafting departments in manufacturing lines, desires position as mechanical engineer or assistant to superintendent or manager.

H-810 Member, age 30, technical graduate in mechanical engineering, seven years practical experience in engine and heavy machinery design, desires position of responsibility with progressive concern or consulting engineers engaged in the manufacture of prime movers and heavy machinery, or designing, construction and operation of power plants. Salary $200-$225.

H-811 Member, M. I. T. graduate, age 40, eight years experience structural design and as superintendent, eleven years varied and valuable experience in mechanical design and manufacture, including four years in turbine design, specialty of stresses and smaller mechanisms, desires position where this experience can be applied. At present, safety assistant for large corporation. New England location preferred.

H-812 Mechanical engineer, technical graduate, age 30, desires responsible position. Thorough knowledge of all types of pumps and pumping machinery, gasoline and oil engines, steam engines and sugar house machinery, also drawing room, erection room and engineering department experience in large pump manufacturing company; sugar plantation work in Mexico and sales engineer in Brazil.

H-813 Member, technical graduate, age 33, ten years experience in light metal manufacturing and foundry work; thoroughly familiar with modern and economic methods of shop management, seeks position as superintendent, preferably with large company. Salary $5000. At present employed.

H-814 Junior, age 38, sales engineer, experienced in handling high-grade power transmission and mechanical specialties, desires to represent manufacturer. Eastern or middle west preferred.

H-815 Junior, age 23, graduate mechanical engineer of Columbia University, one year practical experience, desires position as assistant to manager or superintendent in industrial concern. Location immaterial.

H-816 Junior, age 31, married, 12 years experience heating and ventilating, estimating, drafting and machine design, five years residential engineer for well known company, executive ability, capable of taking entire charge of design and specifications for heating and power plants, purchasing of equipment and materials, desires position with reliable concern or consulting engineer with chances for advancement. At present employed.

H-817 Mechanical engineer, technical graduate, 15 years shop and mill experience, desires important position as plant engineer, or would consider taking an interest with services in small manufacturing enterprise turning out mechanical goods.

H-818 Member, technical graduate, age 32, nine years experience in design and testing of steam turbines and centrifugal air compressors, including blast furnace compressors, desires a position where this experience will be of value; unusual experience in turbine research work, during last three years has determined the leading dimensions and tested a complete line of turbines 100 to 2500 kw. capacity.

H-819 Mechanical engineer, ten years experience with responsible firms in hoisting and conveying machinery, cement plants, general manufacturing and maintenance, office, shop and field.

H-820 Cornell graduate, 28, married, seven years experience as machinist, tool maker and master mechanic, desires

position teaching experimental engineering, mechanics or physics in or near New York. At present employed.

H-821 Member, mechanical engineer, age 38, married, 14 years experience in design, construction and operation, wishes position with cement manufacturing company with chances of advancement; recently superintendent of a large plant; salary moderate.

H-822 Member, graduate M. E., 15 years experience, seven years in connection with manufacture and sale of medium and heavy weight machinery as responsible executive assistant to high officials; duties have included pushing out products, systematization, analysis of costs, short cut estimates, general office management and sales; interested in similar position or one connected with manufacturing or sales department exclusively.

H-823 Member, wide experience in shop and office, five years confidential aid to consulting engineer, having general charge of drafting room and design of railway and lighting power plants, special apparatus, etc., handling reports, specifications and correspondence, wants responsible position as engineer with operating company, manufacturing concern or consulting engineer.

H-824 Junior, age 27, technical graduate, five years experience in automobile factory building high priced cars, desires position as assistant superintendent or manager.

H-825 Member, managing sales engineer, open for contract, has handled successfully well known accounts accepting all responsibility of the entire office; diplomatic and progressive, broad acquaintance in the manufacturing, engineering and contracting field. Location New York and East.

H-826 Member, graduate M. I. T. in mechanical engineering, post graduate course in electrical engineering, wide experience in design and construction of machinery and buildings, manufacturing, systematizing and accounting, desires permanent position in New York.

H-827 Member, age 40, 18 years engineering experience, six years of which have been buying and inspecting machinery and supplies, desires position as purchasing agent; have been buying at lowest prices for resale to largest consumers and can reduce costs.

H-828 Member, mechanical engineer, desires responsible position; 14 years experience in power plant work, heating, ventilating, mill engineering and factory; executive ability; best references.

H-829 Junior, age 27, graduate mechanical engineer, desires position with engineering firm or in industrial plant; four years experience in general plant work in design and construction of machinery and buildings; one year with boiler concern, also shop and testing experience. At present employed.

H-830 Student Member, 1914 M. E., graduate of middle west university, experience on practically every type of farm machinery, wishes position as apprentice or shop workman in factory that specializes in improved farm machinery.

H-831 Member, age 33, 11 years general experience in design and construction of mill buildings, furnaces, boiler, machinery and mechanical equipment of power plants, structures for conveying, elevating and storing coal, ores and other materials. Has acted as chief draftsman, superintendent of construction, mechanical engineering and manufacturing plants. Position desired along these lines; location immaterial but prefer middle West.

ACCESSIONS TO THE LIBRARY

WITH COMMENTS BY THE LIBRARIAN

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary Am. Soc. M. E.

ABHANDLUNGEN UND BERICHTE ÜBER TECHNISCHES SCHULWESEN. Vol. 5. *Arbeiten auf dem Gebiete des Technischen Hochschulwesens. Berlin, 1914.* Gift of Verein deutscher Ingenieure.

ACHT VORLESUNGEN ÜBER THEORETISCHE PHYSIK GEHALTEN AN DER COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK IN FRÜHJAHR 1909, Max Planck. *Leipzig, 1910.*

AMERICAN ASSOCIATION OF DEMURRAGE OFFICERS. Proceedings of the 25th annual convention, 1914. *St. Louis, 1914.* Gift of Association.

AMERICAN MANUFACTURERS EXPORT ASSOCIATION. Proceedings of 4th annual convention, 1913. *New York, 1913.* Gift of Association.

AMERICAN RAILWAY ASSOCIATION. Proceedings of session held in New York City, May 20, 1914. Gift of Association.

AMERICAN RAILWAY ENGINEERING ASSOCIATION. Manual, 1911. *Chicago, 1911.*

AMERICAN SOCIETY OF SWEDISH ENGINEERS. List of Members May 15, 1914. *Brooklyn, 1914.* Gift of Society.

AMERICAN WATER WORKS ASSOCIATION. Proceedings of the 33d annual convention, 1913. *Troy, 1913.* Gift of Association.

ATLANTIC DEEPER WATERWAYS ASSOCIATION. 6th annual convention, 1913. *Philadelphia, 1913.* Gift of Association.

AUTOMATIC SPRINKLER PROTECTION, Gorham Dana. *Boston, 1914.*

BOSTON METROPOLITAN WATER AND SEWERAGE BOARD. 13th annual report. *Boston, 1914.* Gift of the board.

BRIDGES OF NEW YORK CITY, R. K. Thomson. Reprinted from *Engineering Magazine,* September-October, 1909. Gift of author.

COMPUTATIONS FOR MARINE ENGINES, C. H. Peabody. *New York, 1913.*

DESIGN AND CONSTRUCTION OF OIL ENGINES, with an appendix on marine oil engines, A. H. Goldingham. ed. 4. *New York, 1914.*

DIESELMOTOREN. A. Riedler. *Vienna, 1914.*

THE ELASTICITY AND ENDURANCE OF STEAM PIPES. C. E. Stromeyer. *London, 1914.* Gift of Master Steam Users' Association.

ELECTRIC TOURING, presenting a number of electric automobile tours in New York, New Jersey and Connecticut. New York Electric Vehicle Association. Gift of Association.

ENGINEERS HANDBOOK OF TABLES, CHARTS AND DATA ON THE APPLICATION OF CENTRIFUGAL FANS AND FAN SYSTEM AND MOTORS, AIR WASHERS, HOT BLAST HEATERS AND SYSTEMS OF AIR DISTRIBUTION. Published by Buffalo Forge Company. *Buffalo, 1914.*

ENTWERFEN UND BERECHNEN VON HEIZUNGS UND LÜFTUNGSANLAGEN, Otto Wieprecht. ed. 4. *Halle a S., 1910.*

ERECTING AND OPERATING: An educational treatise for constructing engineers, machinists, millwrights and master builders, William Rogers. *New York, 1913.*

ERGERNISS DER BERATUNGEN DES DEUTSCHEN AUSSCHUSSES FÜR TECHNISCHES SCHULWESEN ÜBER HOCHSCHULFRAGEN. *Berlin, 1914.* Gift of Verein deutscher Ingenieure.

FITTING AND ERECTING OF ENGINES, C. L. Browne. *Manchester, 1914.*

FOUNDATIONS OF BRIDGES AND BUILDINGS, H. S. Jacoby and R. P. Davis. *New York, 1914.*

ZUR GESCHICHTE DER DRAHTSEILSCHWEBEBAHNEN, Franz M. Feldhaus. *Berlin, 1911.*

HANDBUCH DER INGENIEURWISSENSCHAFTEN. pts. 3, 5. *Leipzig, 1914.*

HEAT, E. M. Shealy. *New York, 1914.*

HOISTING MACHINERY FOR THE HANDLING OF MATERIALS, T K. Thomson. Reprinted from Engineering Magazine. Gift of author.

HYDRAULIC TABLES, G. S. Williams and Allen Hazen. ed. 2. *New York, 1911.*

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS. Twenty-ninth annual report, 1914. *Wheaton, 1914.* Gift of the society.

ILLINOIS WATER SUPPLY ASSOCIATION. Proceedings of 6th meeting, 1914. *Urbana, 1914.*

INSULATED RETURN FEEDER SYSTEM FOR MITIGATING ELECTROLYSIS INSTALLED BY THE UNITED RAILWAYS COMPANY OF ST. LOUIS, MO., IN THE ANN AVENUE SUBSTATION DISTRICT, Report on. May, 1914. Gift of S. S. Wyer.

INTERNATIONAL (15th) CONGRESS ON HYGIENE AND DEMOGRAPHY. Washington, Sept. 23-28, 1912. Transactions. vol. 1, pt. 1-2; vol. 5, pts. 1-2; vol. 6. *Washington, 1913.*

KONDENSWASSER-ABLEITER, DEUTSCHE-ENGLISCHE, AMERIKANISCHE. PRAKTISCHE RATSCHLÄGE FÜR DAMPFKESSELBESITZER, Robert Wagner. *Leipzig, 1911.*

LECTURES DELIVERED AT THE JOHNS HOPKINS UNIVERSITY IN MAY, 1914, L. G. McPherson. *Baltimore, 1914.*

DIE MASCHINEN-ELEMENTE IHRE BERECHNUNG UND KONSTRUKTION, C. Bach. ed. 11, bd. I. *Leipzig, 1913.*

MODERN PACKING HOUSE, F. W. Wilder. *Chicago, 1905. Gift of Hunt Memorial Fund.*

MÜNCHEN-TECHNISCHEN HOCHSCHULE. BERICHT ÜBER DAS STUDIENJAHR, 1912-1913. *Munich, 1914.* Gift of Technischen Hochschule.

——— Program 1913-1914. *Munich, 1914.* Gift of Technischen Hochschule.

NEW ORLEANS SEWERAGE AND WATER BOARD. Semi-annual report 28th, 1913. *New Orleans, 1913.* Gift of the board.

NEW YORK METROPOLITAN SEWERAGE COMMISSION. Report, 1914. *New York, 1914.* Gift to the commission.

OIL FUEL FOR STEAM BOILERS, R. T. Strohm. *New York, 1914.*

POOR'S MANUAL OF PUBLIC UTILITIES, 1914. *New York, 1914.*

POWER AND POWER TRANSMISSION, E. W. Kerr. ed. 3. *New York, 1914.*

PRACTICAL PATTERN MAKING, F. W. Barrows. ed. 2. *New York, 1914.*

SCHUBSTANGEN UND KREUZKÖPFE, H. Frey. *Berlin, 1913.*

SCIENTIFIC DETERMINATION OF THE MERITS OF AUTOMOBILES, A. Riedler. *London.*

"THE SHIPBUILDER" ANNUAL INTERNATIONAL NUMBER, 1914. *Newcastle-upon-Tyne, 1914.* Gift of Shipbuilder.

SLIDE-RULE NOTES, H. C. Dunlop and C. S. Jackson. *London, 1913.*

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION. Proceedings of 21st annual meeting. vol. 21. *Ithaca, 1914.* Gift of Society.

SPINNEREI UND WEBEREI, Georg Lindner. *Karlsruhe.*

STRENGTH OF MATERIALS, H. E. Murdock. *New York, 1911.*

TECHNICAL THERMODYNAMICS, Gustav Zeuner, translation by J. F. Klein. vols. 1-2. ed. 2. *New York, 1908.*

TRADE CATALOGUES

AEROTHRUST ENGINE CO., *Chicago, Ill.* The Aerothrust for the mechanical propulsion of rowboats, canoes and small sailing craft. The Aerothrust for the mechanical propulsion of bicycles, ice craft, wind wagons, etc.

BACHARACH, HERMAN, *Pittsburgh, Pa.* Catalog B. Hydro volume and pressure recorders.

CONSOLIDATED EXPANDED METAL CO., *Pittsburgh, Pa.* Steel-crete guards, 34 pp. Universal slab computer.

GARRETT, RICHARD, & SONS, *Leiston, England.* The "Garrett" superheated steam semi-stationary engine.

JOHNS-MANVILLE, H. W., CO., *Cleveland, Ohio.* J-M Roofing salesman, May 1914.

LINK BELT CO., *Philadelphia, Pa.* Book no. 190. Wagon and truck loaders, 1914.

NORTH WESTERN EXPANDED METAL CO., *Chicago, Ill.* Expanded metal construction, June 1914.

OTIS ELEVATOR CO., *New York, N. Y.* Escalators, 35 pp.; hand power elevators, 28 pp.; incline railways, 27 pp.; Inclined elevators, 32 pp.; residence elevators; traction elevators, 23 pp.; gravity spiral conveyors. Description of following: Ceiling machine with motor direct connected; double belt ceiling type machine; double screw alternating current machine with full magnet controller; electric sidewalk hoist with hand rope control; hydraulic plunger sidewalk hoist; plunger passenger elevator level control; single screw direct current electric elevator switch control; standard hydraulic elevator vertical cylinder geared type; traction elevator overhead type direct current switch control; duplex geared traction elevator overhead type switch control; single geared traction elevator overhead type switch control.

PACIFIC FLUSH-TANK CO., *Chicago, Ill.* Miller appliances, designed for sewage disposal. Catalog no. 15, automatic air-lock apparatus for flushing sewers and handling sewage. Watertight sewer joint compounds.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ABRIDGED LIST OF OFFICERS AND COMMITTEE CHAIRMEN[1]

JAMES HARTNESS, *President* CALVIN W. RICE, *Secretary*

R. M. DIXON, Finance Committee
H. R. COBLEIGH, House Committee
LEONARD WALDO, Library Committee
L. P. ALFORD, Committee on Meetings
THEO. STEBBINS, Committee on Membership
C. I. EARLL, Publication Committee
FRED J. MILLER, Public Relations Committee
R. H. RICE, Research Committee
JESSE M. SMITH, Committee on Constitution and By-Laws

LOCAL MEETINGS

Atlanta: J. S. Coon
Boston: R. E. Curtis
Buffalo: W. H. Carrier
Chicago: Paul P. Bird
Cincinnati: J. B. Stanwood
Milwaukee: E. P. Worden
Minnesota: Max Toltz
New Haven: H. B. Sargent
New York: R. V. Wright
Philadelphia: H. E. Ehlers
San Francisco: Robert Sibley
St. Louis: F. E. Bausch

[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1914, and in the January and July 1914 issues of The Journal.

PERSONAL NOTES

John W. Nickerson has accepted a position with the Cheney Brothers Silk Mills, in South Manchester, Conn., as industrial engineer, having recently resigned from a similar position with the Sayles Bleacheries, Saylesville, R. I.

S. Warren Potts has resigned as mechanical engineer of the E. W. Bliss Company, Brooklyn, to accept a similar position with R. Hoe & Company, New York.

Lucius L. Moses has opened an office as consulting engineer in Seattle, Wash.

Frederick L. Farrell has resigned from the B. F. Sturtevant Company, New York, to enter the employ of the Green Fuel Economizer Company, also of New York.

Victor E. Schmiedeknecht, designer for the Aurora Automatic Machinery Company of Chicago, has accepted a similar position with the Pneumatic Jack Company, Louisville, Ky.

Henry Martin Leland has become president and advisory manager of the Cadillac Motor Car Company, Detroit, Mich.

Forrest E. Cardullo, professor of mechanical engineering at New Hampshire College, Durham, N. H., has resigned to take a position in the University of Texas, Austin, Tex.

Henry E. Longwell, formerly consulting engineer for the Westinghouse Machine Company, is now general manager of the Westinghouse Air Spring Company, New Haven, Conn.

Ferdinand Jehle, formerly associated with the Commercial Engineering Laboratories, Detroit, Mich., has been appointed laboratory engineer for the Automobile Club of America, New York City.

Samuel S. Webber, recently resigned as chief engineer of the Trenton Works of the American Steel & Wire Company, Trenton, N. J., after 25 years of service.

R. E. Chandler, dean of engineering of the Oklahoma Agricultural and Mechanical College, has resigned to become head of the mechanical engineering department of the New Hampshire College, Durham, N. H.

R. H. Danforth, for the past six years with the United States Naval Experiment Station and the post graduate department of engineering of the United States Naval Academy, Annapolis, has been appointed professor of hydraulics and mechanics at the Case School of Applied Science, Cleveland, Ohio.

W. C. Rowse, who has been experimental engineer with the Cutler-Hammer Manufacturing Co., New York, since April 1913, has been appointed professor of mechanical engineering at the University of Manitoba, Winnipeg, Manitoba, Canada, and will take up his new duties September 1.

Frederick B. Garrahan has severed his connections with the International Nickel Co., Bayonne, N. J., to accept the position of superintendent in charge of steam shovel work of J. N. Bastress & Co., Fern Glen, Pa.

EMPLOYMENT BULLETIN

Note: In sending applications stamps should be enclosed for forwarding.

The Secretary considers it a special obligation and pleasant duty to be the medium of securing positions for members, and is pleased to receive requests both for positions and for men. The published notices of "men available" are made up from members of the Society. Notices are not repeated except upon special request. Names and records are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month.

POSITIONS AVAILABLE

715 Small factory in Massachusetts building box machinery and saw mills, desires superintendent. Man familiar with modern machine shop and foundry practice; 32 men employed.

721 Technical graduate, with some experience as machinist and in erecting and installing machinery; headquarters Chicago. Salary about $100 per month.

801 Lecturers in general mechanical engineering subjects for the coming season; Canadian University; approximate salaries $1250 to $1500.

802 Assistant engineer for small concern in Eastern Pennsylvania, to have charge of handling of orders, estimating, assist chief draftsman in interpreting orders and correspondence, handling of all correspondence in connection with orders, sales records, and possibly occasional selling. Apply by letter.

804 Young engineer with several years experience, wanted for condenser department of Philadelphia concern, to lay out condenser plants and make necessary estimates and calculations. Graduate of the mechanical engineering department of the University of Pennsylvania preferred. Apply by letter.

805 Young engineer, recent graduate or with possibly a year's experience; work will consist of boiler tests, gas analyses, sampling of coal and ash, and possibly some steam engine indicator work and miscellaneous testing. Salary sixty dollars a month.

MEN AVAILABLE

I-900 Student member, eight years experience mechanical drafting room, one year civil engineering, steel works, and two and one-half years superintendent in small shops, desires position as assistant superintendent in large shop or superintendent in small shop.

I-901 Graduate mechanical engineer, age 30, married, at present holding responsible executive position, plant manager, with small manufacturing concern, desires a similar position or one as assistant to superintendent or manager with company with good chance for advancement. Six and one-half years varied engineering experience. Specialty, pressed steel both light and heavy.

I-902 Associate-Member, age 29, experience in design and development of marine motors and gas tractors, boat building, reconstruction of automobiles and trucks; technical correspondent and systematizer; experimenting and investigating work. Inventive ability along practical lines. Position desired as designing or experimenting engineer or executive. Can make a good proposition to capitalist to develop marine oil engine for specialized field.

I-903 Member, technical graduate, experienced in executive work of large corporations, also wide training in the requirements of a corporation or consulting engineer for work such as design of power plants and machinery, their construction, maintenance and operation, purchasing and executive charge of engineering work. Desires a position as works manager or superintendent.

I-904 Graduate mechanical engineer, age 28, married, seven years experience as machinist, toolmaker and master mechanic. Desires position in testing work, design or teaching.

I-905 Member, age 30, mechanical engineer, 14 years experience as draftsman, checker, designer and manager, last employed as American representative for large English engineering firm taking entire charge of sales, advertising, developing new ideas, and general office work. Has traveled all over United States. Desires similar position. Can furnish best references. Location New York.

I-906 Member with education and experience as marine engineer desires to communicate with any persons intending to fit out sea-going ships under the American flag in the present European crisis. Is profitably employed and is willing to consider only a more profitable connection.

I-907 Junior, graduate mechanical engineer, two years experience in power plant engineering and two years indus-

trial engineering, systematizing and managing large plant, desires position with engineering firm or in industrial plant.

I-908 Junior member, M. E. Purdue University, age 26, careful, painstaking, progressive, executive ability, three years experience in machine and power plant design, at present and for past year in charge of erection and equipment of factory buildings. Desires to locate permanently with reliable concern as assistant to mechanical engineer or works manager. Best references.

I-909 Junior member, graduate mechanical engineer, age 27, three years drafting and general engineering experience, desires position with engineering or construction company. Salary $100 per month. Location immaterial.

I-910 Member, mechanic, designer, organizer and executive, good ability, practical experience, interested in devising methods for reduction of manufacturing costs, desires position along these lines with progressive company, or would join smaller company in position requiring all-round experience.

I-911 Member, mechanical engineer, twenty years experience in power plants, heating, ventilating, plumbing, machine tools, refrigerating machines, gas and oil engines and general engineering work, inventive and executive ability, English, French and German correspondent, desires position with consulting engineers. Salary $3000. Location New York or vicinity.

I-912 Junior, M. E., age 24, experienced in design high grade stationary machinery, engines, hoists, compressors, blowers, pumps and condensers, desires position where this experience will be of value. At present employed but desires to locate in New York or vicinity.

I-913 Member, age 32, 12 years experience, desires position as executive or mechanical engineer. Can take full charge of engineering department with concern that wants results and where there is opportunity to advance. Salary $2700-3600. At present employed.

I-914 Student member, age 25, experience in gas engine work as tester, experimental, and assistant engineer with one of the oldest and largest concerns in the country, desires position with gas engine manufacturing company, preferably small, along these lines.

I-915 Sales engineer, technical graduate, ten years experience in successful plant operation and management, desires position in steam, hydraulic and mill equipment. Salary and commission. At present employed.

I-916 Junior, technical graduate, age 25, married, five years experience in shop and office on light machinery and electrical specialties, desires executive position. Salary secondary consideration if opportunity for advancement is good.

I-917 Member, mechanical engineer, graduate of leading technical school, five years' experience in machine shop as machine designer; twelve years experience as patent attorney, has been admitted to Bar. Desires position of responsibility in patent law department of manufacturing company. Some inventive ability.

I-918 Junior, age 38, broad experience in handling high grade mechanical specialties and acquaintance in manufacturing and engineering fields, desires to represent manufacturer in East or Middle West.

I-919 Junior, age 27, graduate mechanical engineer, four years experience in general plant work, including drafting room and shop, desires position with chance for advancement. At present employed.

I-920 Mechanical engineer, ten years experience drafting and machine design, last four years experimental work, desires position along these lines, or as chief engineer, assistant to superintendent or outside man.

I-921 Mechanical engineer, age 30, experienced in pumps and pumping machinery, gasolene, oil and steam engines, sugar house machinery, drawing and erection room, also sales experience, desires responsible position.

I-922 Member with exceptional mechanical and electrical technical training, five years experience in research work on steam turbines and centrifugal air compressors, five years chief engineer complete charge of designing, manufacturing, testing and installing vacuum cleaner systems, including development of portable and stationary vacuum cleaning machines, desires position where his experience and training can be applied. Development engineering preferred.

I-923 Junior, age 27, technical graduate, nine years experience in drafting and design of steam power and industrial plants, heating and ventilating systems, also testing, desires position with broader outlook as mechanical engineer or assistant to superintendent of industrial firm. At present employed. East or Middle West preferred.

I-924 Stevens graduate, age 23, past thirteen months with large steel company, desires position with industrial engineers or as assistant to manager of an industrial concern.

I-925 Member, Cornell graduate, two years post graduate study in Germany, age 39, four years experience as instructor and ten years as designer of steam engines and steam turbines, desires position as assistant professor of mechanical engineering.

I-926 Member, technical graduate, age 35, with shop, design, sales and management experience, wide acquaintance with manufacturers in New England and having an established office in one of the leading manufacturing cities in Connecticut, desires to act as manufacturers' agent for responsible companies.

I-927 Graduate University of Cincinnati, age 24, four years experience as machinist, foundry experience, and one year's experience in power plan construction and design, would consider position with good chance for advancement, or as instructor in engineering or technical school.

I-928 Junior, age 32, technical graduate, post graduate course with large electric works, twelve years experience in design, construction and operation of power houses and substations, experienced in high voltage design and construction. Best references as to character and ability. Salary $200. Location New York.

I-929 Technical graduate, age 33, ten years experience in light metal manufacturing and foundry work; thoroughly familiar with modern and economic methods of shop management, seeks position as superintendent, preferably with large company. At present employed.

I-930 Mechanical engineer, ten years wide and varied experience in the lines of heavy and special machinery, also general manufacturing and maintenance work. Designing, testing and demonstration experience.

I-931 M. I. T. graduate in mechanical engineering, post graduate course in electrical engineering, twenty years experience in design and construction of machinery and buildings, manufacturing, systematizing and accounting, desires permanent position.

I-932 Mechanical engineer, fifteen years experience shop work, road work, power plant operation, design and testing, special, and automatic machinery, also heating, desires position in the East.

I-933 Factory superintendent or foreman, conversant with modern shop practice, executive and mechanical ability; twelve years practical experience production efficiency, maintenance and operation of industrial plants and equipment and systematizing of shops. Location immaterial.

I-934 Student member, M. E. 1911, desires position in shop of manufacturing concern with view to entering sales department.

I-935 Associate-Member thoroughly familiar with large compound condensing and non-condensing Corliss engines, also steam engine indicator practice, desires position as construction or operating engineer.

I-936 Electrical and mechanical engineer, 38, first-class executive, who has headed large organizations, both in constructional and manufacturing work, charge of important government work. Experienced in sales organization, aggressive and a good developer. Desires position with manufacturing or construction company. Apply through the Society.

I-937 Cornell graduate, mechanical and electrical engineer with fourteen years broad experience in the design, erection, operation and appraisal of public service and industrial properties, factory operation and maintenance; and sales engineering. Desires a permanent position with consulting engineers or manufacturing company in or near New York City. Appraisal engineering preferred.

I-938 Student Member, age 23, graduate of Middle West University, 1914 M. E., experience as machinist, mechanical draftsman and rate setter, desires position as assistant to superintendent or to manager of some industrial concern. Location immaterial.

I-939 Member, for the past 13 years connected in various capacities with the operation, extension and improvement of steam power plant systems and with successful record, desires to connect, preferably with an industrial concern wishing to employ a high grade engineer capable of operating a similar plant or chain of plants to best advantage and analytically treating economical development. Age 35. Married. At present employed.

I-940 Managing sales engineer, open for contract to build up business with New York as headquarters. Has specialized in power plant equipment, contractors and conveying machinery. Practical shop and field experience; diplomatic and progressive.

I-941 Member, technical graduate, several years experience designing, testing and erecting, desires position as chief draftsman, mechanical engineer or designer of steam pumps, simplex or duplex. At present employed.

I-942 Member, age 43, married. Three years at Mass. Inst. Tech., thoroughly experienced in railway car designing and building. All positions from draftsman to proprietor. Thorough knowledge of export business, 3 years in South America as salesman. Best references.

I-943 Member, technical graduate; 37 years of age; 15 years experience in teaching Manual Arts subjects, drawing and machine design, kinematics of machinery, building construction, steel and concrete construction, steam and other engineering subjects, desires to correspond with progressive concerns contemplating the engagement of a sales engineer. Exceptionally well-fitted both in training and personality for such a position. Location, preferably Eastern States.

I-944 Member, technical graduate, twelve years experience design and installation of power plants, heating and ventilating systems and shop equipments.

I-945 Junior, technical graduate with experience in shops, drafting room, test plant, engineering and erection departments of large manufacturing concern, desires position with engineering or manufacturing concern.

I-946 South American Markets. Mechanical and electrical engineer, nine years with large corporation, broad engineering and responsible executive experience, can arrange to go to South America with South American gentleman speaking Spanish fluently and familiar with business and social customs of those countries, for the purpose of investigating South American markets. Exceptional opportunity for American manufacturers.

ACCESSIONS TO THE LIBRARY

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This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

AIR BRAKE ASSOCIATION. Proceedings of the 21st Annual Convention, 1914. *Boston, 1914.* Gift of the association.

AQUITANIA, THE CUNARD QUADRUPLE-SCREW ATLANTIC LINER. Souvenir number of The Shipbuilder. *Newcastle-upon-Tyne, 1914.*

ATLANTIC DEEPER WATERWAYS ASSOCIATION. Proceedings of Annual Convention, 1st-5th. *Philadelphia, 1909-1912.* Gift of the association.

CINCINNATI WATERWORKS DEPARTMENT. Annual Report, 1913. *Cincinnati, 1914.* Gift of the department.

CONNECTICUT SOCIETY OF CIVIL ENGINEERS. Proceedings, 1913-1914. *New Haven, 1914.*

DAS EISENBAHNWESEN DER SCHWEIZ, Placid Weissenbach. pt. 1. *Zurich, 1913.*

FUEL ECONOMY AND CO_2 RECORDERS, A. R. Maujer and C. H. Bromley. *New York, 1914.*

METHODS OF MACHINE SHOP WORK, F. A. Halsey. *New York, 1914.*

METROPOLITAN SEWERAGE COMMISSION OF NEW YORK. Supplementary Report on the Disposal of New York's Sewage. June 30, 1914. Gift of the commission.

NEW HAVEN CHAMBER OF COMMERCE. Year Book, 1914. *New Haven, 1914.* Gift of C. W. Rice.

NOTES ON DEPRECIATION OF NATURAL GAS WELLS, Samuel S. Wyer. Columbus. Gift of the author.

POLYTECHNIC ENGINEER. vol. 14. *Brooklyn, 1914.* Gift of Polytechnic Institute of Brooklyn.

RAILWAY LIBRARY, 1913, Slason Thompson. *Chicago, 1914.* Gift of author.

RUSSIAN SOCIETY FOR TESTING MATERIALS. Proceedings. (In Russian.) vol. 1, 1911. *Moscow, 1912.*

ST. LOUIS PUBLIC LIBRARY. Annual Report, 1913-1914. *St. Louis, 1914.* Gift of Public Library.

TECHNICAL MECHANICS, STATICS AND DYNAMICS, Edward R. Maurer. ed. 3. *New York, J. Wiley & Sons, 1914.*

A text book of theoretical mechanics for engineering students. This edition is entirely rewritten. W. P. C.

THROUGH ROUTES FOR CHICAGO'S STEAM RAILROADS, G. E. Hooker. *Chicago, 1914.* Gift of The City Club of Chicago.

EXCHANGES

ACETYLENE JOURNAL. vol. 5, nos. 2-4-12; vol. 9, nos. 3-4; vol. 11, nos. 4-6; vol. 12, nos. 9, 10, 12; vol. 13, nos. 1, 4, 5, 7, 10. Chicago, 1903-1904, 1907, 1909, 1911-1912.

ECOLE D'APPLICATION DU GENIE MARITIME. Cours de Construction du Navire. Tome 4. 1910-1912.

INSTITUTION OF MECHANICAL ENGINEERS. Proceedings, 1913, pts. 3-4. *London, 1913.*

——— List of Members, March, 1914. *London, 1914.*

INSTITUTION OF CIVIL ENGINEERS. Minutes of Proceedings. vol. 194. *London, 1914.*

KONIG. INSTITUUT VAN INGENIEURS. Naamlijst der Leden, June 27, 1914.

KONINKLIJK INSTITUUT VAN INGENIEURS. Catalogus der Boekerij derde supplement, 1914. *s-Gravenhage, 1914.*

SOCIETY OF AUTOMOBILE ENGINEERS. Transactions, vol. 9, pt. 1. *New York, 1914.*

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS. Trans., vol. 21. *New York, 1913.*

WESTERN AUSTRALIAN INSTITUTION OF ENGINEERS. Report of the Council, 1912-1913.

UNITED ENGINEERING SOCIETY

ANUARIO DE LA AMÉRICA LATINA, 1914. *Barcelona, 1914.*

CASPAR'S TECHNICAL DICTIONARY ENGLISH-GERMAN AND GERMAN-ENGLISH. Milwaukee.

CELLULOID: ITS RAW MATERIAL, MANUFACTURE, PROPERTIES AND USES. Fr. Böckmann, translated from the third revised German edition by Chas. Salter.

CHAPTERS ON PAPERMAKING, Clayton Beadle. vols. 1-5. *London, 1907-1909.*

CHEMICAL GERMAN, F. C. Phillips. *Easton, Pa., 1913.*

CORTEZ ASSOCIATED MINES. Report—January 1910 to July 1912; October 1, 1913. *Boston.* Gift of Olaf Wenstrom.

DESIGN OF STEEL MILL BUILDINGS AND THE CALCULATION OF STRESSES IN FRAMED STRUCTURES, M. S. Ketcham. ed. 3. *New York, 1913.*

DICCIONARIO TÉCNICO EN ESPAÑOL, FRANCÉS, INGLÉS Y ALEMÁN, D. Carlos Huelin y Arssu. *Madrid, 1910.*

HANDBUCH DER ZIEGELEITECHNIK, R. Weber. *Berlin, 1914.*

INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY (9TH). Preliminary announcement, July 26-August 8, 1915, St. Petersburg. Gift of Geo. F. Kunz.

KEY TO THE ARCHITECTS OF GREATER NEW YORK. 1914. *New York, 1914.*

LOCKWOOD'S DIRECTORY OF THE PAPER, STATIONERY AND ALLIED TRADES. 39th ed. 1914. *New York, 1914.*

MANUFACTURE OF LEATHER, H. G. Bennett. *London, 1909.*

MANUFACTURE OF LUBRICANTS, SHOE POLISHES AND LEATHER DRESSINGS, Richard Brunner. Translated from the 6th German edition by Chas. Salter. *London, 1906.*

MAP OF THE NORTHERN PEAKS OF THE GREAT RANGE WHITE MOUNTAINS, N. H., Louis F. Cutter, 1914. Gift of author.

MODERN FLAX, HEMP, AND JUTE SPINNING AND TWISTING, H. R. Carter. *London, 1907.*

MOODY'S MANUAL OF RAILROADS AND CORPORATION SECURITIES. vol. 2. Industrial and Public Utility Section. *New York, 1914.*

MUNICIPAL INDEX. August 1912-December 1913. *New York.*

NEW YORK TIMES INDEX. vol. 2, April-June 1914. *New York, 1914.*

ORIENTATION OF BUILDINGS OR PLANNING FOR SUNLIGHT, William Atkinson. *New York, 1912.*

PAVING AND MUNICIPAL ENGINEERING. vols. 1-21, 24-31. *Indianapolis, 1890-1901, 1903-1906.*

POWER-LOOM WEAVING, Anton Gruner. Translated by Chas. Salter. *London, 1900.*

PRACTICAL HANDBOOK OF MODERN LIBRARY CATALOGING, W. W. Bishop. *Baltimore, 1914.*

PRACTICAL PAPER-MAKING, George Clapperton. ed. 2. *London, 1907.*

RAMIE (RHEA) CHINA GRASS, Herbert A. Carter. *London, 1910.*

READER OF SCIENTIFIC AND TECHNICAL SPANISH FOR COLLEGES AND TECHNOLOGICAL SCHOOLS, C. DeWitt Willcox. *New York, 1913.*

RUBBER, ITS SOURCES, CULTIVATION AND PREPARATION. Harold Brown. *London, 1914.*

SPACE OCCUPIED BY WATER TUBE BOILERS, C. R. D. Meier. Paper read before Associated Engineering Societies, April 30, 1913. *St. Louis.*

SUPERHEATING, C. R. D. Meier. Reprinted from Journal of Engineers Society of Pa. *St. Louis.*

A TEXT-BOOK OF PHYSICS. Edited by A. W. Duff. ed. 3. *Philadelphia, 1913.*

THESAURUS DICTIONARY OF THE ENGLISH LANGUAGE, Francis A. March and F. A. March, Jr. 1910 ed. *Philadelphia.*

TREATISE ON CEMENT SPECIFICATIONS, Jerome Cochran. *New York, 1912.*

TREATISE ON THE LAW OF PUBLIC UTILITIES OPERATING IN CITIES AND TOWNS, O. L. Pond. *Indianapolis, 1913.*

U. S. POST OFFICE DEPARTMENT. Specifications for the Construction of Steel Full Postal Cars, and Fixtures Therein.

UTILIZATION OF WOOD-WASTE, Ernst Hubbard. Translated from the German by M. J. Salter. *London, 1902.*

WAHRSCHEINLICHKEITSRECHNUNG, Emanuel Czuber. ed. 2 vols. 1-2. *Leipzig, 1908, 1910.*

WOOD PRODUCTS, DISTILLATES AND EXTRACTS, P. Dumesny and J. Noyer. *London, 1908.*

TRADE CATALOGUES

BEST MANUFACTURING CO., *Pittsburgh, Pa.* Catalog and hand book of piping materials for steam, air, hydraulic, no. 103, 1912.

CLINTON WIRE CLOTH CO., *Clinton, Mass.* Steel Fabric, May, 1914.

DEUTSCHE MASCHINENFABRIK A. G., *Duisburg, Germany.* Founders and managers of our works, past and present, 90 pp.

GARTENFELD CABLE WORKS, description of. Gift of K. G. Frank.

HEINE SAFETY BOILER CO., *St. Louis, Mo.* Boiler Logic, 28 pp.; Superheater Logic, 11 pp.; large Heine boilers, 4 pp.

H. W. JOHNS-MANVILLE CO., *Cleveland, O.* J.-M. Power Expert, June, 1914; J.-M. Roofing Salesman, June, 1914.

KOEHRING MACHINE CO., *Milwaukee, Wis.* Koehring mixer, June-July 1914.

LESCHEN, A., & SONS ROPE CO., *St. Louis, Mo.* Leschen's Hercules, June, 1914.

PELS, HENRY & CO., *London, Eng.* List 55. Hand Lever, punching, shearing and cropping machines.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ABRIDGED LIST OF OFFICERS AND COMMITTEE CHAIRMEN[1]

JAMES HARTNESS, *President* CALVIN W. RICE, *Secretary*

R. M. DIXON, Finance Committee
H. R. COBLEIGH, House Committee
LEONARD WALDO, Library Committee
L. P. ALFORD, Committee on Meetings
THEO. STEBBINS, Committee on Membership
C. I. EARLL, Publication Committee
FRED J. MILLER, Public Relations Committee
R. H. RICE, Research Committee
JESSE M. SMITH, Committee on Constitution and By-Laws

LOCAL MEETINGS

Atlanta: J. S. Coon
Boston: R. E. Curtis
Buffalo: David Bell
Chicago: S. G. Neiler
Cincinnati: J. B. Stanwood
Milwaukee: E. P. Worden
Minnesota: Max Toltz
New Haven: H. B. Sargent
New York: R. V. Wright
Philadelphia: H. E. Ehlers
San Francisco: Robert Sibley
St. Louis: F. E. Bausch

[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1914, and in the January and July 1914 issues of The Journal

PERSONALS

William C. Adams, formerly associated with the Chase Metal Works, Waterbury, Conn., as engineer, has accepted the position of assistant superintendent of the Detroit Copper and Brass Rolling Mills Company, Detroit, Mich.

W. N. Dickinson has become associated with the General Elevator Company of New York. He was until recently manager of the foreign department of the Otis Elevator Company, New York, prior to which he was temporarily in charge of their Chicago works and Middle West construction, and later had charge of their engineering on the Pacific Coast.

R. C. Hargreaves has accepted the position of traffic engineer of the Federal Motor Truck Company, Detroit, Mich.

Fred B. Corey, formerly for eleven years in the engineering department of the General Electric Company, and for the past three years engineer of inspection and tests of the Union Switch and Signal Company, has resigned that position and opened an office in the Arrott Building, Pittsburgh, Pa. He will conduct a consulting engineering business, making a specialty of inspection methods and organizations for manufacturing companies, and will also give attention to electric railway signalling and allied subjects.

A. F. Barnes, formerly with the engineering departments of the University of Pennsylvania and Middlebury College, has been appointed dean of engineering of New Mexico State College, State College, New Mexico.

M. I. Nasim is now connected with the turbine department of the Westinghouse Machine Company, East Pittsburgh, Pa. He was until recently identified with the turbine engineering department of the General Electric Company, Lynn, Mass.

Charles A. Waring has severed his connections with the National Cash Register Company, Dayton, Ohio, as draftsman of the electric engineering department, and is now associated with the engineering department of the Reo Motor Car Company of Lansing, Mich.

Arthur R. Jealous, formerly associated with the General Electric Company, Boston, Mass., has accepted the position of assistant superintendent of works of the Clark Thread Company and Clark Mile End Spool Cotton Company, Newark, N. J.

Sverre Petersen has become affiliated with the Southern Well Works Company, Chattanooga, Tenn., as chief engineer. He was until recently connected with the Henry R. Worthington Company, Harrison, N. J., in the capacity of mechanical engineer.

P. C. Philipp, for many years on the staff of the American Appraisal Company and of late in charge of the valuation department for Day & Zimmerman, Philadelphia, has opened an office of his own in Philadelphia. He will specialize on valuation of public utilities exclusively. Mr. Philipp has been retained by a number of Ohio companies to make a valuation of their properties.

A. L. Breckenridge has severed his connection with the Narragansett Electric Lighting Company, Providence, R. I., as building inspector, and is now employed as a draftsman by the Pennsylvania Steel Company, Steelton, Pa.

Eilert Nesdahl, formerly in the employ of the Buffalo Forge Company, Buffalo, N. Y., has accepted a position with Warren Webster & Company, Camden, N. J.

Edward J. Kunze, who for the past four years has been assistant professor of mechanical engineering in charge of machine design and construction at the Michigan Agricultural College, East Lansing, Mich., has been appointed professor of mechanical engineering in charge of the department of mechanical engineering at the Oklahoma Agricultural and Mechanical College, Stillwater, Okla.

EMPLOYMENT BULLETIN

Note: In sending applications stamps should be enclosed for forwarding.

The Secretary considers it a special obligation and pleasant duty to be the medium of securing positions for members, and is pleased to receive requests both for positions and for men. The published notices of "men available" are made up from members of the Society. Notices are not repeated except upon special request. Names and records are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month.

POSITIONS AVAILABLE

809 Designers with experience on either hull or engine work; also designers on marine steam boilers and piping. Salary four to six dollars per day. Location Baltimore, Maryland.

810 Engineer thoroughly experienced in design and operation of modern oil engines. Location Illinois.

811 Manufacturing superintendent on gas engine work; must be thoroughly experienced in modern methods, and possess tact and energy. Excellent opportunity in broad line for man with ability.

900 Energetic, ambitious young man to sell power plant equipment. Technical graduate preferred. Experience as salesman not essential, but preferred. Excellent opportunity for right man. Location Pittsburgh. Apply through Society.

901 Instructor in experimental engineering; prefer one several years out of college with both practical and teaching experience. Salary $1100 to $1200. Location Pennsylvania.

902 Chief draftsman for turbine department of forty to fifty men; preference given to one familiar with large steam apparatus and capable of handling design of large machines and a good disciplinarian. Apply through Society.

903 Experienced graduate, mechanical and electrical engineer, familiar with problems incidental to the construction, improvement and maintenance of iron and steel works. State experience and salary desired, also references as to ability and character. Apply through Society.

904 Assistant to chief engineer of sugar factory; must have knowledge of electrical machinery and practical experience. Location Porto Rico. Salary $125 per month with board.

909 Several men to represent Michigan concern in exclusive territories. Positions call for a thorough knowledge of boiler equipment and selling experience. Apply through Society.

910 Draftsman, if possible one with knowledge of agricultural implements. Location Massachusetts. Salary according to ability, probably one hundred dollars a month to start. Position permanent and good opportunity for advancement. Apply by number through the Society.

912 Engineer to take entire charge of factory in New York, manufacturing portable metal furniture. Apply through the Society.

MEN AVAILABLE

J-1000 Junior, graduate mechanical engineer, four years experience in office, testing and sales for company manufacturing pumps and air compressors, one year editorial work with magazine devoted to internal combustion engines, desires position in commercial line, preferably sales. At present employed.

J-1001 Member, M.I.T. graduate, age 36, wide experience in manufacture of machinery and exporting, desires to act as manufacturer's export representative in New York.

J-1002 Student member, Stevens 1914 graduate, desires position with contracting concern or consulting engineer. Location immaterial.

J-1003 Member, technical graduate, age 32, experience as machinist, shipping clerk, draftsman, master mechanic, mechanical engineer, assistant superintendent and superintendent, competent to take position as general manager of plant employing several hundred men. Location New York preferred.

J-1004 Superintendent, age 39, broad experience in designing tools and labor saving devices for increasing production in interchangeable manufacturing work. Expert in punch press work and construction of dies for sheet metal stamping and forming. Has had complete charge of plant. Location preferred in the East.

J-1005 Mechanical graduate, age 30, three years experience technical advertising, six years engineering instructor, well versed in theory and practice. Salary $3000.

J-1006 Mechanical engineer, technical graduate with successful selling experience, contemplates opening office in Chicago. Would like to hear from manufacturers desirous of having their product marketed in Chicago and surrounding territory.

J-1007 Young engineer, technical graduate, has had experience in repair work of locomotives and charge of several important tests, desires to locate near New York. At present employed.

J-1008 Member, graduate Stevens Institute of Technology, age 33, energetic and reliable, successful executive, four years experience as chief draftsman, two years as production superintendent, and two years as mechanical superintendent, desires position as factory manager or general superintendent. At present employed.

J-1009 Junior, M.I.T. graduate, journeyman machinist, experienced in design, inspecting, research, steam power, repair work and correspondence, desires position with consulting engineers or manufacturing concern, preferably in the South. At present employed.

J-1010 Associate-Member, age 28, desires an opportunity, with possibilities for advancement. Specialty steam turbines and steam power plant equipment. Will sacrifice salary for real opportunity. At present employed.

J-1011 Member with broad shop experience in medium and heavy work desires to connect with progressive concern requiring the services of a capable superintendent.

J-1012 Technical graduate, mechanical engineer, Stevens '03, ten years experience in drafting and engineering work, also manufacture of water gas and soap. Five years with large anthracite coal operating company in eastern Pennsylvania in design, erection and maintenance of machinery for handling and dressing coal.

J-1013 Member, technical graduate, age 35, married, 15 years experience designing, erecting and operating high grade steam power plants. Special attention given to improvements in plants and fuel economy, thoroughly familiar with handling California crude oil as fuel. Location preferred California or some other part of the West.

J-1014 Major interest will be assigned in foreign patents in consideration for putting new device on the U. S. market, or for providing means to do so. The device is applicable to machinery in general, including automobiles, and has been thoroughly tried out in practice. U. S. patents were recently granted.

J-1015 Member, mechanical and electrical engineer, technical graduate, Assoc. A.I.E.E., 15 years practical experience, 12 years in executive positions as chief electrician, power plant chief engineer, mechanical engineer and master mechanic, successful in handling men, thoroughly familiar in engineering correspondence, compiling plant reports, commercial testing, etc. desires position with large mining and smelting companies. At present employed. Location immaterial, but prefer South or West.

J-1016 Junior, graduate M.I.T., age 29, married, five and one half years experience in design and construction of power plants, desires executive position, assistant to superintendent, or manager with company with good chance for advancement. At present holding responsible position.

J-1017 Associate-Member, graduate mechanical engineer, thoroughly familiar with designing and testing of air compressors, blowing engines, vacuum pumps using plate valves and large steam engines (drop valve gear), also commercial experience, desires responsible position. Knowledge of French and German.

J-1018 Junior, age 26, married, eight years shop and drafting room experience on small and medium size machinery. Steady, industrious worker, systematic, accurate at figures and good correspondent, desires position in shop or office. Location immaterial but prefer New England or New York. Salary $100 per month.

J-1019 Mechanical engineer with eleven years experience as engineer and superintendent in varied manufacturing lines open for engagement November first.

J-1020 Mechanical engineer, technical graduate, ten years experience automatic machinery and experimental work, desires executive position with chance for advancement. At present employed.

J-1021 Junior, Stevens graduate, age 30, capable executive in new and re-construction and equipment of mills and factories; designer along electrical and steam power lines, structural and reinforced concrete architecture, desires an engagement. At present chief engineer for metropolitan firm of industrial engineers now completing new manufacturing plant in South.

J-1022 Member, technical graduate, with commercial training, speaking five languages, fully conversant with Latin and South American trade conditions, 18 years varied experience in design and construction of machinery and buildings, remodeling, maintenance and operation of industrial plants and equipment; systematizing of shops and processes along scientific management lines, testing and general plant engineering; familiar with handling men, drawing up contracts, purchasing equipment and material, appraising properties, modern methods of manufacturing and marketing products, desires to become identified with manufacturing or industrial plant in responsible administrative or executive position. At present employed.

J-1023 Manufacturing superintendent or shop manager, good organizer and executive, familiar with modern and economical manufacturing methods including the premium and bonus systems and time study. Successful in increasing production and reducing costs without adding new equipment; thorough knowledge of the value and efficiency of the latest improved manufacturing machines.

J-1024 Graduate mechanical engineer, age 28, married, 12 years experience in shop, drafting and design of European Diesel oil engines, automatic machinery and industrial plants, desires position as mechanical engineer, or assistant to superintendent of industrial firm. At present employed.

J-1025 Member, 25 years experience in design and construction of machinery, building crushing plants, power plant work and mill engineering, also familiar with purchasing of materials and equipment, desires to be identified with manufacturing or industrial plant in responsible position.

J-1026 Junior, Columbia University graduate, one year practical experience designing and testing air machinery, power plants and industrial processes to discover losses and determine costs of production, desires position as assistant

to manager or superintendent of industrial concern. Location immaterial.

J-1027 Cornell graduate, age 28, married, six years experience at blast furnace, steam specialties and motor cars; four years high class motor trucks and carriages, one year in charge small factory office, wishes opportunity in executive line. Location and travel immaterial.

J-1028 Member now located on the Pacific coast, for many years connected with a large steel company in this country, desires to establish an agency representing a number of reputable Eastern manufacturers.

J-1029 Mechanical engineer, technical graduate, age 30, knowledge of Spanish-American business, sugar plantation work and sales engineer, thorough knowledge of gasolene, oil and steam engines, all types of pumps and pumping machinery and sugar house machinery.

J-1030 Mechanical and electrical engineer, technical graduate, 14 years experience in design, operation and appraisal, broad knowledge of several branches of engineering and keen insight particularly fit for investigations and reports, desires permanent position in or near New York.

J-1031 Member, graduate M.E., with experience in export of hydraulic and pneumatic machinery, also internal combustion motors, associated with old established importing and exporting house in New York, open for export agency; lines of small foolproof machinery, special tools, valves, alloys, etc., preferred.

J-1032 Member, technical graduate, desires position as mechanical engineer or assistant to superintendent or manager; experienced as chief draftsman in manufacturing lines.

J-1033 Graduate engineer, age 32, single, technical knowledge mechanical and electrical engineering, 12 years practical experience design, construction and operation of steam power plants, hydroelectric plants and sub-stations, piping layouts, etc., desires position with consulting engineer or large contracting firm. Salary $175. Location New York or vicinity.

J-1034 Mechanical engineer with offices in London, England, who has successfully introduced various railway specialties of American manufacturers in Europe, is open to negotiate with prominent manufacturers of railway rolling stock and specialties with a view to establishing and extending their export business in Great Britain and its colonies. Highest references.

J-1035 M. I. T. graduate in mechanical engineering, post graduate course in electrical engineering, twenty years experience in design and construction of machinery, and buildings, manufacturing, systematizing and accounting, desires permanent position.

J-1036 Junior, Stevens graduate, age 30, varied experience in office of consulting engineer, complete charge of work and considerable responsibility; experience in reports, designs and appraisals of numerous industrial and power plants and municipal works. Best references.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

Aeronautical Society of America. Constitution, by-laws list of members, etc., *1914*. *New York, 1914*. Gift of C. W. Rice.

Asphalts, their Sources and Utilizations. T. Hugh Boorman. 1914 road edition. *New York, 1914*. Gift of author.

This is the second edition of the work. It treats of the origin and uses of asphalt especially in road construction, and is profusely illustrated with full page plates of existing roads. W. P. C.

Association of Railway Telegraph Superintendents. Proceedings of Annual Meeting, 1914. *Milwaukee, 1914*. Gift of association.

Association of Transportation and Car Accounting Officers. Proceedings, June 1914. Gift of association.

Cement Mills Electric Drive, an Analysis of Its Benefits, T. H. Arnold. *Philadelphia*.

Cotton Combing Machines, T. Thornley. *London, 1902*.

Gear Cutting in Theory and Practice, J. G. Horner. *Manchester, 1914*.

Illinois Water Supply Association. Proceedings of 5th Meeting, 1913. *Urbana, 1913*.

Institution of Civil Engineers of Ireland. Index to Transactions, 1845-1910. *Dublin, 1911*. Gift of G. E. Stechert & Co.

Instructions for Making Improvement Thinnings and the Management of Moth-infested Woodlands. H. O. Cook and P. D. Kneeland. *Boston, 1914*. Gift of Mass. State Forester.

Iron Ores, Their Occurrences, Valuation and Control, Edwin C. Eckel. *New York*, McGraw Hill Book Co., 1914. Gift of publishers.

Treats of the abundance and wide distribution of iron, and the genesis of iron ore deposits; of the factors affecting the value of iron and the valuation of deposits; on prospecting, mining costs, mill costs as affecting valuation. Then follows a detailed description of the more important ore deposits of the world, with full references to the literature. The final chapters are devoted to an economic study of iron ore resources as affecting the future development of the iron industry, special attention being given to the conditions affecting the American iron industry. W. P. C.

Kansas Engineering Society. Transactions and Report of the 6th Annual Meeting, 1914. *Topeka, 1914*. Gift of society.

Los Angeles (Cal.) Department of Public Utilities. 4th Annual Report of the Board. 1912-1913. *Los Angeles*. Gift of Department of Public Utilities.

Melbourne University Calendar, 1913. *Melbourne, 1912*. Gift of A.S.M.E.

New York State Conservation Commission. 2d Annual Report, 1912. *Albany, 1913*. Gift of Commission.

New York State Engineer & Surveyor. Annual Report, vol. 1, 1913. *Albany, 1914*. Gift of New York State Engineer and Surveyor.

Recent Supreme Court Decisions on Engineering Contracts and Liabilities of Sureties upon such Contracts, G. A. King.

La Soudure Autogène. *Paris*.

Springfield (Mass.) Water Commissioners. 40th Annual Report, 1913. *Springfield, 1914*. Gift of Board of Water Commissioners.

Traveling Engineers' Association. Committee Reports and Subjects, 22d Annual Meeting, 1914. Gift of Traveling Engineers' Association.

Uber die Theorie des Kreisels, F. Klein and A. Sommerfeld. pt. 2-4. *Leipzig, 1898, 1903, 1910*.

Uhland's Handbuch für den praktischen Maschinenkonstrukteur. vols. 1-4, 6-13. ed. 2. *Berlin*.

University of Minnesota. College of Engineering, 1914-15. *Minneapolis, 1914*. Gift of University.

Die unmittelbare Umsteuerung der Verbrennunskraftmaschinen, Ch. Pöhlmann. *Berlin, 1914*.

Vereines deutscher Ingenieure. Inhaltsverzeichnis der Zeitschrift, 1877-1883, 1884-1893. *Berlin, 1884, 1895*.

Verein deutscher Ingenieure und Seine Arbeiten, Description of. *Berlin, 1914*. Gift of the Verein.

GIFT OF WILLIAM J. HAMMER

AERONAUTICAL SOCIETY. Official Program, Aviation Decennial Celebration, 1903-1913.

BETTER BUSINESS, Wm. Hard.

CHRONOLOGY OF AVIATION, H. Maxim and W. J. Hammer.

HISTORICAL COLLECTION OF INCANDESCENT ELECTRIC LAMPS.

YOUTHFUL FRANKLIN. An Oration Delivered at the Unveiling of a Statue of Benjamin Franklin in 1723 at the University of Pennsylvania, June 16, 1913, Jas. M. Beck.

GIFT OF NATIONAL COMMERCIAL GAS ASSOCIATION

GAS EQUIPMENT OF THE HOME. *New York, 1914.*

HYGIENIC VALUE OF GAS LIGHTING, R. F. Pierce.

PROPOSED GAS FIXTURE SPECIFICATIONS AS RECOMMENDED BY THE COMMITTEE ON STANDARDIZATION OF GAS APPLIANCE SPECIFICATIONS. 1913.

PROPOSED GAS RANGE SPECIFICATIONS AS RECOMMENDED BY THE COMMITTEE ON STANDARDIZATION OF GAS APPLIANCE SPECIFICATIONS. 1912.

TRADE CATALOGUES

ELECTRIC WEIGHING CO., *New York, N. Y.* Bull. no. 8. Messiter conveyor scales, 15 pp.

FERRO MACHINE & FOUNDRY CO., *Cleveland, O.* Ferro rowboat motor, 16 pp.

FLANNERY BOLT CO., *Pittsburgh, Pa.* Staybolts, July 1914.

GARDNER MACHINE CO., *Beloit, Wis.* Gardner Grinder, May-June 1914.

GAS MACHINERY CO., *Cleveland, O.* Form 390. New coal gas plant of Porto Rico Gas Co., San Juan, Porto Rico, 16 pp.

LESCHEN, A., & SONS ROPE CO., *St. Louis, Mo.* Leschen's Hercules, July 1914.

LUNKENHEIMER CO., *Cincinnati, O.* Lunkenheimer whistles, 23 pp.

NORTH WESTERN EXPANDED METAL CO., *Chicago, Ill.* Expanded metal construction, July 1914.

STEPHENS-ADAMSON MFG. CO., *Aurora, Ill.* Labor saver, no. 64.

UNDER-FEED STOKER CO. OF AMERICA. Publicity Magazine, June, July 1914.

WALWORTH MFG. CO., *Boston, Mass.* Walworth Log, July 1914.

YALE & TOWNE MFG. CO., *New York, N. Y.* Yale Hoisting Hints, July 1914.

UNITED ENGINEERING SOCIETY

AMMONIA AND ITS COMPOUNDS, THEIR MANUFACTURE AND USES, Camille Vincent. Translated from the French by M. J. Salter. *London, 1901.*

ART OF PAPER MAKING, Alexander Watt. Ed. 4. *London, 1911.*

BIBLIOGRAPHIE DER DEUTSCHEN ZEITSCHRIFTEN LITERATUR. Vol. 23. *Leipzig, 1914.*

BIBLIOGRAPHIE DER FREMDSPRACHIGEN ZEITSCHRIFTENLITERATUR. Vol. 8, 1913. *Leipzig, 1914.*

CALCULUS FOR ENGINEERS, John Perry. *London, 1897.*

CARNEGIE ENDOWMENT FOR INTERNATIONAL PEACE. Report of the International Commission to inquire into the causes and conduct of the Balkan Wars. Publication no. 4. *Washington, 1914.* Gift of R. A. Franks.

FORMULES RECETTES, PROCÉDÉS, L. François. *Paris, 1914.*

GESAMT-ZEITSCHRIFTEN VERZEICHNIS. *Berlin, 1914.*

LIQUID AIR OXYGEN, NITROGEN, Georges Claude. *Philadelphia, 1913.*

PREVENTION OF DAMPNESS IN BUILDINGS, Adolf W. Keim. *London, 1902.*

PSYCHOLOGY OF MANAGEMENT, L. M. Gilbreth. *New York, Sturgis & Walton Co., 1914.*

A publication in book form of the essays appearing originally in *Industrial Engineering.* A careful study of the underlying principles of scientific management. W. P. C.

RECENT COTTON MILL CONSTRUCTION AND ENGINEERING, Joseph and Frank Nasmith. Ed. 3. *Manchester, 1909.*

SMALL WATER SUPPLIES, F. Noël Taylor. *London, 1911.*

TEXTILE INDUSTRIES, Wm. S. Murphy. 8 vol. *London, 1912.*

TRADE CATALOGUES

Chicago Pneumatic Tool Co., Chicago, Ill. Ideal Power, July, 1914.

Flannery Bolt Co., Pittsburgh, Pa. Staybolts, August, 1914.

Gardner Machine Co., Beloit, Wis. Gardner Grinder, July-August, 1914.

Hess-Bright Mfg. Co., Philadelphia, Pa. Ball bearings in machine tools, 1914.

Sherwood Mfg. Co., Buffalo, N. Y. The "Hart" oil pump.

Texas Co., New York, N. Y. Lubrication, July, 1914.

Under-Feed Stoker Co. of America. Publicity magazine, August, 1914.

Walworth Mfg. Co., Boston, Mass. Model Piping Specifications, a Guide for Engineers. Copies can be had by addressing Power Dept., Walworth Log, Sept., 1914.

Winslow Safety High Pressure Boiler Co., Chicago, Ill. Winslow Safety High Pressure Boiler, 53 pp.

Yarnall-Waring Co., Philadelphia, Pa. Log book of the power plant, 88 pp.

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R. M. DIXON, Finance Committee
H. R. COBLEIGH, House Committee
LEONARD WALDO, Library Committee
L. P. ALFORD, Committee on Meetings
THEO. STEBBINS, Committee on Membership
C. I. EARLL, Publication Committee
FRED J. MILLER, Public Relations Committee
R. H. RICE, Research Committee
JESSE M. SMITH, Committee on Constitution and By-Laws

LOCAL MEETINGS

Atlanta: J. S. Coon
Boston: R. E. Curtis
Buffalo: David Bell
Chicago: S. G. Neiler
Cincinnati: J. B. Stanwood
Milwaukee: E. P. Worden
Minnesota: Max Toltz
New Haven: H. B. Sargent
New York: R. V. Wright
Philadelphia: H. E. Ehlers
San Francisco: Robert Sibley
St. Louis: F. E. Bausch

[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1914, and in the January and July 1914 issues of The Journal

PERSONAL NOTES

Charles L. Samson, formerly associated with The Griffin Wheel Company, Chicago, Ill., as mechanical engineer, has accepted the position of master mechanic of The Hamilton Manufacturing Company, Two Rivers, Wis.

Thomas L. Tomlines, until recently connected with the Stebbins Engineering and Manufacturing Company, Watertown, N. Y., has opened a consulting engineering office in the Flower Building, Watertown, N. Y.

Edwin Frank has been appointed instructor in mechanical engineering at the University of Illinois, Urbana, Ill. He was formerly in the hydraulic department of Allis-Chalmers Manufacturing Company, West Allis, Wis.

Harold V. Coes, until recently associated with Lockwood, Greene & Company, Boston, Mass., as special principal assistant, has become affiliated with the Sentinel Automatic Gas Appliance Company, New Haven, Conn., as vice-president and general manager.

R. F. Peters has resigned as mechanical engineer of the San Antonio and Aransas Pass Railway, San Antonio, Texas, to accept an appointment as senior mechanical engineer of the division of valuation, Interstate Commerce Commission, with headquarters at Kansas City, Mo.

J. H. Billings, who at the outbreak of the war was in England on his way to Germany to take a years course of study at the University of Berlin, is now taking a course for a master's degree in mechanical engineering at Massachusetts Institute of Technology.

William J. Dyer has terminated his connection with the Honolulu Iron Works Co., Honolulu, Hawaii, after 15 years service as designing and construction superintendent of machinery for the sugar industry, and with a broad practical knowledge of engineering in its various branches, announces the opening of an office as consulting engineer in the Stangenwald Building, Honolulu, Hawaii.

Mr. Alfred E. Kornfeld, who relinquished his connection with "Engineering News" in 1912 after 18 years service, has again become identified with it and as a member of its business staff, with headquarters in New York City.

Mr. H. deB. Parsons has been appointed joint representative of both the Chamber of Commerce and the Society on a special Board of the City of New York to formulate specifications for fire hose and tests for same.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

The first meeting of the season was held on October 8. C. W. Naylor, Member of the American Society of Mechanical Engineers, spoke on the benefits derived from belonging to an engineering society. Other speakers were Prof. G. F. Gebhardt, Member of the American Society of Mechanical Engineers, Professors Peebles, Libby, Anderson, and Roesch and L. W. Bunge.

KANSAS STATE AGRICULTURAL COLLEGE

The following officers were installed at a meeting of the Kansas State Agricultural College Student Branch held on October 1: Prof. A. A. Potter, honorary chairman; J. E. Bengston, president; R. A. Shelly, vice president; L. A. Wilsey, secretary; R. L. Swenson, treasurer. R. L. Swenson reviewed the Journals for July, August and September. J. B. Lund, Superintendent of Heat and Power of the Kansas State Agricultural College, gave an interesting talk on the practical problems of heating buildings. Prof. A. A. Potter, Dean of the Engineering Division, gave a short discussion on the functions and various activities of the American Society of Mechanical Engineers, and Professor Reid of the Electrical Engineering Department gave a short address on the importance of college sections of the national engineering societies.

OHIO STATE UNIVERSITY

The first regular meeting of the Ohio State University Student Branch was held on October 7 and the following officers were elected: R. D. Rogers, chairman; P. W. Sheatsley, secretary; F. M. Atwell, treasurer. T. W. Herbst was chosen to take charge of the athletic activities of the branch. The chairman appointed C. L. Brown, C. Lauer, R. M. Matthews and P. W. Sheatsley to serve as a program committee and L. R. Baker, A. R. Furnas and H. D. Winbigler to comprise a social committee. Prof. Wm. T. Magruder, honorary chairman of the branch, spoke of the relation of the branch with the American Society of Mechanical Engineers, and suggested several ways by which benefit from the Society could be increased. Prof. F. E. Sanborn gave an interesting talk on "The Qualities of an Engineer."

RENSSELAER POLYTECHNIC INSTITUTE

The first regular meeting of the student branch of the Rensselaer Polytechnic Institute was held on September 24 at which 23 members of the Junior Class were taken into the branch. The following officers were chosen: C. P. Brown, chairman; B. F. Percival, vice-chairman; H. Thieringer, treasurer; W. Kelly, secretary. D. M. Singer gave an interesting talk on power development at Niagara Falls. This was followed by a discussion by Prof. A. M. Greene, W. S. Powers and H. Thieringer.

UNIVERSITY OF COLORADO

The first meeting of the University of Colorado Student Branch was held on September 23. The meeting was devoted to a discussion of future plans and activities of the branch, of the possibility of increase of membership and the selection of a suitable pin for the branch.

UNIVERSITY OF MINNESOTA

At the October meeting of the University of Minnesota Student Branch, Fletcher Rockwood presented a paper on the "Disposal of Municipal Waste." He described in general the various methods used by municipalities in disposing of garbage and other waste and gave a detailed account of the incinerator system as employed in Minneapolis.

UNIVERSITY OF MISSOURI

The first meeting of the University of Missouri Student Branch was held on September 21 and the following officers were elected: L. L. Leach, chairman; Troy Russell, secretary and treasurer; P. R. A. Nolting, corresponding secretary; and Prof. A. L. Wescott, Stanley Goodman and W. A. Sloss, the governing board. At a meeting held on October 5, Dean Davenport of the School of Commerce addressed the Society on the present financial crisis.

UNIVERSITY OF NEBRASKA

The following officers were elected at a meeting of the University of Nebraska Student Branch held October 3: D. W. Watkins, chairman; R. B. Gillespie, treasurer. Prof. J. D. Hoffman gave a short talk on the American Society of Mechanical Engineers and the benefits derived from being a member of engineering organizations.

WORCESTER POLYTECHNIC INSTITUTE

The organization meeting of the Worcester Polytechnic Student Branch was held on October 2. R. H. Crippen, chairman of the branch, gave a short talk telling what the purposes and aims of the branch were. Charles S. Gingrich of the Cincinnati Milling Machine Company gave an illustrated lecture on "Modern High Production Milling Machine Practice," showing some of the exceptional results gained by experimental work performed in their research laboratory. Among those who took part in the discussion of the lecture were Dr. Ira N. Hollis, President of Worcester Polytechnic Institute; W. W. Bird, Professor of Mechanical Engineering and Director of the Institute Shops; John S. Spence of the Norton Grinding Company; Albert A. Gordon of the Crompton & Knowles Company; Clinton Alvord of the Worcester Loom Company.

EMPLOYMENT BULLETIN

Note: In sending applications stamps should be enclosed for forwarding.

The Secretary considers it a special obligation and pleasant duty to be the medium of securing positions for members, and is pleased to receive requests both for positions and for men. The published notices of "men available" are made up from members of the Society. Notices are not repeated except upon special request. Names and records are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month.

POSITIONS AVAILABLE

914 Instructor in machine shop practice for large university in middle west. College man with practical experience preferred.

1035 High grade, practical machine designer, experience in machine, pattern shop and drawing room; one who can make practical designs from a shop standpoint so that goods may be manufactured cheaply and be of such grade as to meet the best of competition. Position permanent for man of ability. Salary according to ability. Location Missouri. Apply by letter.

1036 Massachusetts concern desires young engineer, preferably one with technical education and two or three years shop experience who is willing to start with reasonable salary and work into estimating and planning department. Apply by letter.

1121 A well established company, manufacturing a line of railroad specialties, covering both rolling stock and road bed, desires to add to its output other articles in keeping with present lines.

MEN AVAILABLE

K-1100 Graduate Stevens Institute of Technology, age 44, married, good executive, broad experience in designing and experimenting with internal combustion engines, also thorough knowledge of "service" work for large automobile concern, desires position in or near New York.

K-1101 Junior member, college graduate, three years engineering department of large eastern steel company; two years assistant superintendent and chief engineer large electric company in charge of engineering and construction departments, designing, estimating, erecting and directing work; competent in designing and building power plants, sub-stations, transmission lines, electric cranes and tram cars, coal and ash handling systems, piping layouts, boiler and engine settings and machinery installation, desires position of authority and responsibility with chance for advancement.

K-1102 Junior member, age 29, graduate mechanical engineer, five years experience in design of steam electrical generating equipment; four years as sales engineer; specialist in modern electrical power generation for industrial manufacturing plants, boilers, all types of steam turbines, generators, condensers and auxiliaries, desires position with an engineering, manufacturing or public utility company. Large acquaintance in western Pennsylvania and eastern Ohio.

K-1103 Junior, Cornell graduate, age 26, two years experience in erecting testing and installing compression and absorption refrigerating machines and several years experience as superintendent of street paving and general construction work, desires permanent position which will lead to advancement in sales, executive or general engineering capacity. Location immaterial, eastern states preferred.

K-1104 Mechanical engineer, technical graduate with wide machine shop and mill experience, desires position with large progressive manufacturer. Would consider taking part interest in small but live manufacturing proposition in New England.

K-1105 Technical physicist, M.I.T. graduate in mechanical engineering, can organize and equip physical testing laboratories, and take charge of research problems in turbine or similar work. Interview in Boston the last week of November or in New York at the Annual Meeting.

K-1106 Associate member, age 32, seven years technical training, four years shop apprentice, drafting and designing steam and pumping engines, also two cycle double acting and four cycle oil engines, desires a change. Has held positions as outside engineer, chief engineer and master mechanic. Executive ability in handling men. Location immaterial.

K-1107 Factory superintendent or general foreman with broad experience in modern manufacturing methods can produce results with your equipment; twelve years experience with production efficiency and organizing of shops.

K-1108 Technical graduate in mechanical engineering, three years practical experience including design, shop management, purchasing and sales work. Last employed as superintendent of company making high grade gasolene motors and would like something of similar nature. Salary $1600.

K-1109 Junior, M.I.T. graduate in mechanical engineering, experienced in all branches of building, construction, especially estimating and cost systems, also sales engineer. Location immaterial.

K-1110 Member, graduate mechanical engineer, 20 years experience as designer and draftsman of simplex and duplex steam pumps, desires position as designer or chief draftsman. Best references.

K-1111 Student member, technical graduate with eight years gas engine experience. At present employed as steam engineer but desires gas engine field.

K-1112 Associate-Member, A.S.M.E., Associate, A.I.E.E., graduate Stevens Institute of Technology, age 26, four years with large electrical manufacturer, two years at factory, remainder of time selling and investigating power requirements of factories, making motor recommendations, figuring comparative costs and presenting them in form of reports, experienced in indicating steam engines. At present engaged in manufacturing line but desires sales work.

K-1113 Superintendent with wide experience in modern methods in foundries, machine shops and manufacturing plants, expert mechanic, good executive able to produce maximum results with equipment and men.

K-1114 Junior, graduate mechanical engineer, five years experience in manufacture and design of high grade automobiles, desires position as assistant superintendent with growing concern. At present engineer of tests in automobile factory building its own parts.

K-1115 Member, 18 years experience as draftsman, superintendent and chief engineer, ten years in selling, will go anywhere in the United States north of the Ohio River. Has proved ability in steel casting specialties.

K-1116 Member, age 34, experienced in design and construction of propelling machinery for steam vessels, desires responsible executive position in similar line of work. At present superintendent in large manufacturing concern but prefers marine engineering.

K-1117 Junior, technical graduate in mechanical and electrical engineering, 12 years practical experience in design, construction and maintenance of sub-stations and power houses high voltage design and construction, gas and gasolene engines. At present employed in responsible position. Salary $175. Location New York.

K-1118 Junior, age 38, sales engineer, broad experience in handling high grade mechanical specialties, acquaintance in manufacturing and engineering fields, desires to represent manufacturers in east or middle west. At present employed.

K-1119 Mechanical engineer with eleven years experience in varied manufacturing lines open for engagement.

K-1120 Member, technical graduate, ten years experience in civil, mining and mechanical engineering, wishes extra work in drafting, designing or calculating. At present employed in Philadelphia.

K-1121 Member, technical training as mechanical engineer, as well as shop training as machinist and superintendent; eight years experience conducting an office as designing and contracting engineer, is open for engagement as representative of high grade concern, preferably in field of equipment for the handling of materials. Location Ohio and adjacent states.

K-1122 Junior, experienced in designing and testing air machinery, power plants and determining costs of production, desires position as assistant to manager, superintendent of industrial concern, or sales.

K-1123 Junior, M. I. T. graduate, journeyman machinist, experienced in design, inspecting, research, steam power, repair work and correspondence, desires position with consulting engineers or manufacturing concern, preferably in the South. At present employed.

ACCESSIONS TO THE LIBRARY

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

American Ceramic Society. Transactions, vol. XVI, 1914. *Columbus, 1914.* Gift of Society.

American Society of Agricultural Engineers. Transactions, vol. 6, 7, 1912-13. *Madison, 1912-13.* Gift of Society.

American Society of Mechanical Engineers. Transactions, vol. 35, 1913. *New York, 1914.*

Association of Harvard Engineers. Year Book, 1913. Gift of A. S. M. E.

Business Methods in Municipal Works. *Philadelphia, 1913.* Gift of Department of Public Works of Philadelphia.

Carnegie Endowment for International Peace. Year Book, 1913-14. *Washington, 1914.* Gift of Carnegie Endowment for International Peace.

Carnegie Foundation for the Advancement of Teaching. 6th Annual Report of the President. *New York, 1911.* Gift of Carnegie Foundation for the Advancement of Teaching.

Chemistry of Combustion Applied to the Economy of Fuel. E. W. Dimond. *Worcester, 1867.* Gift of Dr. Tolman.

Elements of Electricity and Magnetism. Wm. S. Franklin and Barry Macnutt. *New York,* Macmillan Co., 1913. Gift of publishers.

The book has been prepared for college use. An attempt has been made "to rationalize our experience of physical conditions and things." W. P. C.

Experiments in the Preservative Treatment of red-oak and hard-maple cross ties. Francis M. Bond. U. S. Dept. of Agriculture, Forest Service, Bull. 126. *Washington, 1913.* Gift of F. M. Bond.

International Railway General Foremen's Association. Proceedings. 10th Annual Convention, 1914. Gift of Association.

Maine. State Water Storage Commission. 3d and 4th Annual Report, 1912, 1913. *Waterville, 1913-1914.* Gift of Geo. L. Fowler.

Manchester Steam Users' Association for the Prevention of Steam Boiler Explosions. Memorandum by Chief Engineer, 1913. *Manchester, 1914.* Gift of Manchester Steam Users' Association.

Master Boiler Makers' Association. Official Proceedings of 7th, 8th Annual Convention, 1913, 1914. Gift of Geo. L. Fowler.

Minnesota Conservation and Agricultural Development Congress, March 16-19, 1910. Address delivered at St. Paul, 1910. Gift of A. S. M. E.

National Paving Brick Manufacturers' Association. Directions for laying Vitrified brick street pavements. No. 1 Specification. *1911.*

——— Specifications for the construction of vitrified brick street pavements and vitrified brick highways. Gift of Association.

New Jersey Board of Public Utility Commissioners. 4th Annual Report, 1913. *Union Hill, 1914.* Gift of New Jersey Public Utility Commissioners.

New York State Engineer and Surveyor. Supplement to the Annual Report. vol. II, 1913. *Albany, 1914.* Gift of State Engineer and Surveyor.

Nouvelles Recherches sur la Résistance de L'Air et L'Aviation. G. Eiffel. 2 vols. *Paris, Dunod et Pinat, 1914.* Gift of author. (Review will appear in next issue of Journal.)

Poor's Manual of Industrials, 1914. *New York, 1914.*

Proportioning Aggregates for Portland Cement Concrete. Albert Moyer. Gift of Vulcanite Portland Cement Co.

Science Museum (South Kensington). Catalogue of the Mechanical Engineering Collection. Part I. and supplement. *London, 1914.* Gift of Science Museum.

Scientific Management. A collection of the more significant articles describing the Taylor system of management. Edited by Clarence Bertrand Thompson. *Cambridge, Harvard University Press, 1914.* Gift of author.

This is the first of the series "Harvard Business Studies," issued by the Graduate School of Business Administration. Among the numerous articles reprinted are several from the Transactions of the Society. Over eight hundred pages of reprints are given, preceded by a paper on the literature of scientific management, and followed by a good bibliography of the subject. An extremely useful compilation. W. P. C.

Some Tests to Determine the Effect upon Absorption and Penetration of Mixing Tar with Creosote. F. M. Bond. Gift of author.

SOUTH PHILADELPHIA. The abolishment of grade crossings and the creation of opportunities for commercial and industrial development. *Philadelphia, 1913.* Gift of Department of Public Works of Philadelphia.

U. S. COMMISSIONER OF CORPORATIONS ON TRANSPORTATION BY WATER IN THE UNITED STATES. Report. Pts. I-IV. *Washington, 1909, 1910, 1913.* Gift of U. S. Dept. of Commerce and Labor.

VOLTAGE TESTING OF CABLES. W. I. Middleton and C. L. Dawes. *1914.* Gift of Simplex Wire & Cable Company.

WISCONSIN. INDUSTRIAL COMMISSION. Building Code. 1914. *Madison, 1914.* Gift of Commission.

EXCHANGES

BROOKLYN ENGINEERS' CLUB. Proceedings for 1913. *Brooklyn, 1914.*

INSTITUTION OF CIVIL ENGINEERS. Minutes of Proceedings. vol. CXCV. *London, 1914.*

——— Charter, supplemental charters, by-laws and list of members. July, 1914. *London, 1914.*

MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK. Proceedings, 1913. *New York, 1913.*

PURDUE UNIVERSITY. Alumni Register, 1875-1911. *Lafayette, 1912.*

U. S. COMMISSIONER OF PATENTS. Annual Report, 1913. *Washington, 1914.*

TRADE CATALOGUES

BAIRD MACHINE CO., *Bridgeport, Conn.* Bull. 303. Ball burnishing machine.

BRYANT ELECTRIC CO., *Bridgeport, Conn.* Bryant silent call signal system for hospitals. 31 pp.

DURAND STEEL LOCKER CO., *Chicago-New York.* Catalogue E. Steel racks, shelving, factory equipment. Catalogue F. Steel lockers.

GOLDSCHMIDT THERMIT CO., *New York, N. Y.* Reactions. Third quarter, 1914, no. 3.

JOHNS-MANVILLE CO., *Cleveland, O.* The J-M roofing salesman, September, 1914.

LESCHEN & SONS ROPE CO., *St. Louis, Mo.* Leschen's Hercules, September, 1914.

TIMKEN ROLLER BEARING CO., *Canton, O.* Timken magazine, August, October, 1914.

UNDER-FEED STOKER CO. OF AMERICA, *Chicago, Ill.* Publicity Magazine, September, October, 1914.

WALWORTH MFG. CO., *Boston, Mass.* Model piping specifications, September, 1914.

UNITED ENGINEERING SOCIETY

AMERICAN LIBRARY ASSOCIATION. Handbook, 1914. (vol. 8, no. 5, of Bulletin.) *Chicago, 1914.* Gift of W. P. Cutter.

A MAGYAR MÉRNÖKÉS EPITÉSZ-EGYLET 1914. *Budapest, 1914.* Gift of the American Society of Hungarian Engineers.

MOTION PICTURE TRADE DIRECTORY, August 1914. *New York, 1914.* Gift of Frank Wenneis.

NEW INTERNATIONAL ENCYCLOPAEDIA. ed. 2. vols. 3-6. *New York, 1914.*

NEW ZEALAND PATENT OFFICE JOURNAL. vol. 1; vol. 2, nos. 1-8, 10-13, 15-25; vol. 3, nos. 1-4, 6-14. *Wellington, 1912-14.* Gift of Patent Office.

OIL, PAINT AND DRUG REPORTER. Green Book for Buyers, January 1914 edition. *New York, 1914.* Gift of Oil, Paint and Drug Reporter.

PASSENGER CAR VENTILATION SYSTEM OF THE PENNSYLVANIA RAILROAD COMPANY. Chas. B. Dudley. *Altoona, 1914.* Gift of Pennsylvania Railroad Company.

PATENTS. Chas. L. Clarke. Reprinted from "General Electric Review." Gift of author.

PUBLISHERS' TRADE LIST ANNUAL, 1914. *New York, 1914.*

WHO'S WHO IN AMERICA. vol. VIII, 1914-15. *Chicago, 1914.*

TRADE CATALOGUES

BARTLETT & SNOW CO., *Cleveland, O.* Catalogue no. 29. Garbage disposal plants. 1909. Bulletin no. 40. Garbage disposal machinery. Zopp.

CROWN CORK & SEAL CO., *Baltimore, Md.* The Crown cork system. 55 pp.

GRISCOM-RUSSELL CO., *New York, N. Y.* Bulletin 703. Rubbish utilization plant in the city of Pittsburgh, Pa. 704. Report of official tests of Sterling Destructor installed at Halifax, N. S. The Sterling Destructor. 48 pp.

HAMMOND ENGINEERING CO., *Warren, Pa.* Sewage disposal.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ABRIDGED LIST OF OFFICERS AND COMMITTEE CHAIRMEN[1]

JAMES HARTNESS, *President* CALVIN W. RICE, *Secretary*

R. M. DIXON, Finance Committee

H. R. COBLEIGH, House Committee

LEONARD WALDO, Library Committee

L. P. ALFORD, Committee on Meetings

THEO. STEBBINS, Committee on Membership

C. I. EARLL, Publication Committee

FRED J. MILLER, Public Relations Committee

R. H. RICE, Research Committee

JESSE M. SMITH, Committee on Constitution and By-Laws

LOCAL MEETINGS

Atlanta: J. S. Coon
Boston: R. E. Curtis
Buffalo: David Bell
Chicago: S. G. Neiler
Cincinnati: J. B. Stanwood
Los Angeles: Walter H. Adams
Milwaukee: E. P. Worden
Minnesota: Max Toltz
New Haven: H. B. Sargent
New York: R. V. Wright
Philadelphia: H. E. Ehlers
San Francisco: Robert Sibley
St. Louis: F. E. Bausch

[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1914, and in the January and July 1914 issues of The Journal

PERSONAL NOTES

Henry W. Johnson has resigned his position as mechanical superintendent of the Bullard Machine Tool Company, Bridgeport, Conn., and has accepted a position with the Russell, Burdsall and Ward Bolt and Nut Company, Port Chester, N. Y.

Frank A. Mickle has been appointed instructor of descriptive geometry and drawing at the University of Michigan, Ann Arbor, Mich. He was until recently in the employ of the Buckeye Steel Castings Company, Columbus, Ohio, as designer.

Henry W. Abbott has become associated with the Ames Plow Company, South Framingham, Mass., in the capacity of superintendent. He was formerly assistant to the master mechanic of the Pennsylvania Steel Company, Steelton, Pa.

Thomas C. Kelly has resigned his position with the Triumph Ice Machine Company, Cincinnati, Ohio, to engage in consulting engineering work in the same city.

Clarence M. Davison, formerly assistant works manager of the Alberger Pump & Condenser Company, Newburgh, N. Y., has become chief engineer of the Best Manufacturing Company, Pittsburgh, Pa.

A. H. Charles Dalley has resigned his position as Chicago Manager of the Stoker Department of the American Engineering Company to accept a position as sales manager of the Flanner Water Tube Company. Mr. Dalley has opened his headquarters in the Marquette Building, Chicago.

H. L. Seward who last year planned and developed a course for the Junior classes in both mechanical and electrical engineering at Sheffield Scientific School, Yale University in Mechanical Technology, had this year 106 students and 12 assistants in the course which began the first week in September and lasted until the opening of the Fall Term. Each student devoted 8 hours a day to the study of Manufacturing Methods and Power Plant operation in New Haven and vicinity which offers exceptional advantages for such instruction because of the many and diversified industries represented there. Over 40 local firms have coöperated with the Department of Mechanical Engineering. At the Mason Laboratory, The Brown and Sharpe Company of Providence, R. I., had in operation one of its latest 2-A Universal Milling Machines. The expert who operated the machine instructed all students in regard to its design, construction and operation. Last year new machines were exhibited by the National Acme Manufacturing Company, Cleveland, Ohio, and by the Windsor Machine Company, Windsor, Vermont.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

The second regular meeting of the Armour Institute Student Branch was held on November 4. L. D. Kiley gave a talk on Patents and Patent Law. He explained the necessary requirements of a patent before it is patentable and showed some original patent papers which had been issued by the United States Government and foreign countries. He said that special stress is laid on the claims in the patent since the value of a patent lies entirely in its claims. Patent Law was dealt with very briefly because of the scope of the subject.

CARNEGIE INSTITUTE OF TECHNOLOGY

The organization meeting of the Carnegie Institute of Technology Student Branch was held on October 7. The officers for the school year are: J. R. Cline, president; B. Schwartz, vice president; C. W. Gibbs, treasurer; J. Guter, secretary. Professor Trinks, head of the Mechanical Engineering Department of the Institute, spoke on his recent trip to Europe which terminated when the war was declared. He had intended to make a study of smoke prevention and steel works engineering as taught abroad. He told of a very efficient smoke prevention society with headquarters at Hamburg. The operations of this society extend over a large part of Europe although its fees are only five dollars for membership and five dollars for each furnace. This entitles a member to at least one thorough test and possibly two each year. In his study of the teaching of steel-works engineering, he came into contact with many prominent engineers, among them Puppe, inventor of the improved mill for I-beams. Professor Trinks was impressed by the fact that air-compressors in Europe were run at about four times the speed ordinarily used in the United States. The principle of forced lubrication was the chief factor in producing this result.

CASE SCHOOL OF APPLIED SCIENCE

At a meeting of the student branch of the Case School of Applied Science on November 12, the following committees were appointed: Program Committee; Prof. F. H. Vose, chairman, A. C. Kleckner and L. K. Baker: Social Committee; C. P. Diemer, chairman, D. K. Swartwout and H. E. Wills; Publicity Committee; D. S. Stanion, chairman, and L. W. Hodous.

COLUMBIA UNIVERSITY

At a meeting of the Columbia University Student Branch on October 30, R. J. S. Pigott, Engineer of the Interborough Rapid Transit Company, gave a lecture on the Design Problems of the 59th and 74th St. Power Plants, New York City. The problems as outlined by Mr. Pigott consisted in increasing the capacity of the present stations. In the case of the 59th St. Station, the problem was met by adding low pressure turbines to operate on the exhaust steam from the reciprocating engines. In the 74th St. Station, complete turbines were substituted for the reciprocating units. These changes resulted in the reduction of the cost of power and at the same time increasing the capacity of both plants. In order to accomplish these results, mechanical stokers of the underfed type were installed which permitted the operating of the boilers at 300 per cent rated capacity.

LEHIGH UNIVERSITY

At a meeting of the Lehigh University Student Branch on October 13, a paper was read by A. F. Glass, '15, on Measurement of Large Volumes of Gases. His talk was supplemented by illustrations. Mr. Madaga, a special student at the University, discussed tests made in the U. S. Navy in this connection.

The subject of the main talk was Modern Mechanical Engineering by A. A. Shimer, '99, Chief of Service and Maintenance Department of New Jersey Zinc Company. No discussion followed.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The Mechanical Engineering Society of Massachusetts Institute of Technology held its first meeting of the year Oct. 29. The meeting was a "get-together" smoker and the speaker of the evening was Mr. F. H. Fay of Boston, who gave an interesting talk on the Quequechan River Improvements which are being planned for the city of Fall River, Mass. His talk was illustrated by lantern slides, and by means of these the speaker was able to impress upon the minds of all present the decidedly unsanitary conditions which exist in the heart of Fall River due to the discharge of sewage and mill-waste into the Quequechan. Prof. E. F. Miller also spoke on the importance to all mechanical engineering students of joining the Society.

OHIO STATE UNIVERSITY

The Testing of Motor Vehicle Motors was the subject of a lecture given by Prof. F. R. Hutton before the Ohio State University Student Branch on October 16. Prof. Hutton's talk consisted of the answers to the following questions: Why test a motor vehicle? By whom should it be tested? How should it be tested? Results of test.

He pointed out the deficiencies of the road test as per-

formed by the manufacturers for advertising purposes, and declared that no two tests could be compared without considering the differences in climate, roads, tire conditions, and the personality of the driver. He emphasized the fact that a road test could not be duplicated and explained in detail the apparatus and the methods used in testing automobiles at the testing laboratories of the Automobile Club of America. In regard to the muffler, he showed that only 3 per cent more power was gained by the use of the cut-out and that about 200 per cent was deducted from the comfort of the neighborhood. The lecture was illustrated by numerous lantern slides.

At the meeting on October 30, the following papers were presented: The Buckeye-mobile, P. McC. Shafer. This was illustrated by lantern slides; The Alloy Steels, F. M. Herbst; The Layout of the Finishing Department of the Steel Casting Plant of the Gould Coupler Company, C. L. Brown.

PENNSYLVANIA STATE COLLEGE

The Pennsylvania State College Student Section of the A. S. M. E. held a meeting Oct. 29 in the Engineering Club Room, State College, with the following officers presiding: C. F. Kennedy, president; V. D. Longo, vice president; W. Blume, treasurer; D. E. Hewitt, secretary. Plans were begun for a mechanical engineering exhibit to be held at the College on Pennsylvania Day, November 13.

The attendance at the meeting was 35. No technical papers were delivered as the time was devoted to business.

RENSSELAER POLYTECHNIC INSTITUTE

The second meeting of the Rensselaer Polytechnic Institute Student Branch was held on October 29. W. S. Powers gave an interesting talk on the Power Plant of the Rochester and Syracuse Railway, located in Lyons, N. Y.

J. B. Lincoln spoke on the processes in the manufacture of woolen cloth. He showed many samples and illustrations showing the different stages of the process from the shearing of the sheep to the finished product.

UNIVERSITY OF CINCINNATI

The University of Cincinnati Student Branch of the American Society of Mechanical Engineers held its first meeting of the school year 1914-15 on Oct. 15. Prof. F. R. Hutton, Honorary Secretary of the American Society of Mechanical Engineers and Advisory Engineer of the American Automobile Association, spoke on The Relation of the Mechanical Engineer to the Draftsman. He referred to the designing engineer, and showed how shop training of a cöoperative engineering student would make him a better designer. He traced the growth of a machine from a visualization to the finished product, and showed that in each progressive step the credit and responsibility belonged to the engineer. Professor Hutton told how a draftsman could increase his value and better his position by conscientious work, and discussed in detail the liberties which an engineer and a draftsman might enjoy or expect in regard to the work he was doing for his employer. European customs were compared with those of this country, and examples cited.

UNIVERSITY OF COLORADO

A meeting of the University of Colorado Student Branch was held on November 12, at which Professor Hunter gave a talk on A Square Deal in Engineering.

UNIVERSITY OF KANSAS

The first regular meeting of the University of Kansas Student Branch was called to order by the honorary chairman, Prof Sibley. Dean P. F. Walker was elected Honorary Chairman for the year. Other officers elected were: O. T. Potter, chairman; G. A. Rathert, vice chairman; Clyde Maris, recording secretary; S. E. Campbell, treasurer, and I. W. Clark, corresponding secretary.

Dean and Mrs. Walker informally received those present after which Dean Walker gave a short talk on the American Society of Mechanical Engineers as to its purpose, membership, etc.

At a meeting held on October 15, J. E. Stillwell was elected to represent the mechanical engineers on the governing board of the "Kansas Engineer," the engineering magazine of Kansas University. Program and membership committees were appointed by O. T. Potter.

A review of the Journal for the summer months was given by I. W. Clark.

Prof. Sluss gave a talk on the use of engineering handbooks.

UNIVERSITY OF MAINE

At the meeting of the University of Maine Student Branch on November 6, the following officers were elected for the ensuing year: William L. Wark, president; Clifford A. Skillin, vice president; Harry A. Titcomb, secretary and treasurer; John A. Burke, executive committee.

At the meeting on November 12, Prof. L. B. Chapman gave a talk on Hydroplanes. Professor Chapman described the displacement boat and the gradual change from these to the hydroplanes of the present day. The talk was illustrated by lantern slides, which showed views of different hydroplane engines and of the boats themselves. A speed time chart which Professor Chapman himself had computed was shown, which gave the different speeds attained by hydroplanes up to the year 1913.

UNIVERSITY OF MICHIGAN

An open meeting of the University of Michigan Student Branch was held on October 7. The majority of the student members last year were seniors and an open meeting was held in order to arouse interest in the branch and revive the membership at least to its former number and increase it as much as possible.

Mr. Mills, chairman, outlined the purpose of the branch and the benefits derived from the lectures and from the Journal.

Mr. C. F. Hirshfeld, Chief of the Research Department of The Detroit Edison Illuminating Company, gave a talk on The Connors Creek Plant of The Detroit Edison Illuminating Company. The plant, which is not yet completed, is expected to be one of the most economical in the country. Mr. Hirshfeld showed slides illustrating the construction of the plant and then showed some of the methods by means of which the great saving of heat is to be accomplished.

UNIVERSITY OF MISSOURI

A meeting of the University of Missouri Student Branch was held on October 22. Mr. J. W. Haney, assisted by Prof. E. A. Fessenden, read a paper on Heat Transmission in Boiler Tubes, which gave an account of a series of experiments conducted at the University of Missouri Engineering Experiment Station by Mr. Haney and Professor Fessenden.

At a meeting on November 12, J. C. Squirs gave a talk on the new method of Metal Plating and Earl E. Morgan told of some of his experiences in steam turbine work.

UNIVERSITY OF NEBRASKA

At a meeting on November 10, Professor Acendorfer, a graduate of Transvaal and Cornell Universities, gave a lecture on Diamond Mining in South Africa. Professor Adendorfer is a Boer and has spent most of his time in this mining district. He discussed the development of the industry and methods of mining from the beginning up to the present time.

WASHINGTON UNIVERSITY

The following officers for the year 1914-15 were elected by the Washington University Student Branch: Prof. E. L. Ohle, honorary chairman; R. V. Henkel, chairman; W. Brotherton, vice chairman; E. C. Schisler, secretary; J. Summersby, treasurer.

WORCESTER POLYTECHNIC INSTITUTE

At the November meeting of the Worcester Polytechnic Institute Student Branch of the American Society of Mechanical Engineers, Mr. A. T. Marshall, W. P. I. '89, me-

chanical engineer for the Automatic Refrigerating Company, Hartford, Conn., demonstrated their Automatic Refrigerating Machine, one of which was in operation on the laboratory table. After a brief description of cooling processes, the speaker invited the audience to inspect the machine and a general conversation was held relative to its workings.

EMPLOYMENT BULLETIN

Note: In sending applications stamps should be enclosed for forwarding.

The Secretary considers it a special obligation and pleasant duty to be the medium of securing positions for members, and is pleased to receive requests both for positions and for men. The published notices of "men available" are made up from members of the Society. Notices are not repeated except upon special request. Names and records are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month.

POSITIONS AVAILABLE

1035 High grade practical machine designer, experience in machine shop, pattern shop and drawing room; must be a man who can make practical designs from a shop standpoint that goods may be manufactured cheaply and be of such grade as to meet the best competition. Position permanent for man of ability. Salary according to ability. Location Missouri.

1110 Man with expert knowledge in manufacture of abrasives, emery wheels, emery cloths, etc., for position in Japan.

1111 Hustling machine shop general foreman, experienced on engine and pump work; must be a thorough mechanic, able to produce the maximum output of A-1 quality at lowest cost, and familiar with best and latest up-to-date machine shop practice. Give synopsis of experience and state age, experience, references, and compensation expected. Apply by application addressed care of Society.

1125 Draftsman or designers experienced in jig, fixtures and die work, especially those familiar with manufacture of small arms, or experience in sewing machines, typewriter work, etc. Location New York State.

1126 Progressive mechanical engineer to take charge of the mechanical department of pulp and paper mill, including a machine repair shop, also the steam and electrical equipment. Applicant must be graduate of well-known engineering school, preferably Massachusetts Institute of Technology. Prefer young man who has had a few years practical experience, if possible in pulp and paper mills. Position offers good opportunity for advancement for the right man. Give references, age, experience, education and salary expected. Location Pennsylvania.

1127 Electrical engineer for sole management of factory making economical electric lamps. Position in Petrograd, Russia. State salary wanted. Possible time of departure.

MEN AVAILABLE

L-1200 Superintendent, experienced in steam engine and general power plant operation, wishes to connect with firm owning large producer gas engine plant which is causing trouble.

L-1201 Member, technical graduate, with broad experience in the design and supervision of factory or mill buildings, power plants and machinery, purchasing materials and equipment, desires position as purchasing agent or sales engineer. Would consider position as works engineer or superintendent.

L-1202 Technical graduate, 17 years experience in sales, engineering and manufacturing in pumping and power plant machinery. Especially well equipped for position of broad responsibility in moderate sized organization.

L-1203 Member, technical graduate, age 35, shop, design, sales and management experience, wide acquaintance with manufacturers in New England and the Middle Atlantic States, and having established offices in Connecticut and Pennsylvania, desires to act as manufacturers' agent for responsible companies.

L-1204 Junior member, technical graduate, journeyman machinist with all around experience, desires position as assistant to executive in manufacturing concern or with consulting engineers.

L-1205 Member, designing and contracting engineer, practically and technically trained and having an established business acquaintance and practice, desires to add to line of affiliations as representative of first class manufacturers, preferably in the field of equipment for handling materials. Would prefer to cover northern Ohio territory.

L-1206 Junior, age 28, desires position as assistant engineer or assistant superintendent with manufacturing concern.

L-1207 Student member, University of Michigan 1914, M.E., desires position with manufacturing concern or consulting engineers. Will consider any offer with chance for advancement.

L-1208 Manufacturing superintendent or shop manager, 20 years varied experience, good organizer and executive, familiar with modern and economical manufacturing methods including any system of wage payment, expert machine demonstrator and time study man, successful in the design of special labor saving machinery and appliances for interchangeable manufacture, desires change about the first of the year.

L-1209 Member, graduate engineer, seven years experience in design and supervision of installation of mechanical equipment of buildings, power plants and central heating systems; also five years as efficiency engineer, desires position with consulting engineer, architect or private firm.

L-1210 Member, mechanical engineer and factory manager, six years in charge of drafting and designing tools and equipment for large electric plant; past eight years general manager of factory and consulting engineer developing successful registering machine and holding thirty-five patents on it, would like position with concern as mechanical engineer or factory manager. Would also consider charge of drafting room.

L-1211 Mechanical engineer, Stevens graduate, age 30, married, six and one half years varied engineering experience, at present holding responsible executive position as plant engineer with small manufacturing concern, desires similar position or one as assistant to superintendent or manager with company offering good chance for advancement. Specialty, pressed steel, both light and heavy.

L-1212 Member, sales engineer, age 27, five years experience with power plant equipment, desires sales position. At present employed.

L-1213 Associate member, technical graduate, one year teaching, four years in electric traction work including power stations economics, office routine, system and locomotive testing, three years testing and development work of large hydraulic control machinery, including testing of mechanical, electrical and hydraulic apparatus, desires position on design or experimental work in a similar line.

L-1214 Member, graduate engineer, ten years experience in responsible positions in design, construction and operation of portland cement and stone crushing plants, and especially valuable on enlargement and modernization of plants and operations, desires position. Limited knowledge of Spanish.

L-1215 Superintendent, age 39, expert in punch press work and construction of dies for sheet metal stamping and

forming. Broad experience in designing tools and labor saving devices for increasing production in interchangeable manufacturing work. Has had complete charge of plant.

L-1216 Associate-member of the A.S.M.E. and A.I.E.E., college graduate, age 34, experienced as sales engineer and a specialist in efficiency selling methods, with experience in closing large electric power contracts and as sales manager for public utility companies, is open for position with company desiring the services of a capable sales manager.

L-1217 Junior member, Worcester Polytechnic Institute graduate, M.E., age 25, two years experience in mechanical and electrical engineering, consisting of experimental and construction work in steel company.

L-1218 Technical graduate, mechanical engineer, age 31, unmarried, thorough experience in field of engineering which appertains to the multiple use of steam and vapors for boiling and heating. Broad experience in conducting experiments on a large scale, and in handling men. At present in position as designing, experimental, and erecting engineer for large corporation in the West.

L-1219 Member, Cornell graduate, 14 years experience as machinist, inspector, test engineer, draftsman, mechanical engineer, shop superintendent and salesman, with successful experience selling gas power and electric-machinery, steam specialties and gas producers, desires position as salesman or as sales department engineer. Location preferred, Northwestern or Western States. At present employed in western Canada.

L-1220 Junior, graduate mechanical and electrical engineer, experience in mechanical department of railroad in machine shop, roundhouse and office work, desires a position along similar lines with good chance for advancement. South preferred.

L-1221 Superintendent, tactful in handling men, with broad experience in modern machine shop, foundry and manufacturing practice, good designer of tools, appliances and methods for producing interchangeable work at low cost; familiar with time study and modern system of paying for labor, cost keeping, etc.

L-1222 Associate-member, graduate of M.I.T., age 27, Associate, A.I.E.E., constructing experience at M.I.T., also experience as foreman, assistant master mechanic, and assistant superintendent; past two years with Thomas A. Edison; capable of whipping new work into routine shape and presenting results in form of final reports.

L-1223 Member, 12 years practical experience, competent to organize; thoroughly familiar with all modern manufacturing methods and systems, and reducing costs, desires position as factory superintendent or foreman.

L-1224 Mechanical engineer, broad experience in design of factory and mill engineering, familiar with modern shop methods, purchasing of equipment, is open for engagement.

L-1225 Member, graduate of M.I.T., Member A.I.E.E., thorough experience in power generation and applications, ten years experience testing, designing and engineering with large electric company and public utility companies. Familiar with German, French, and Spanish, also some literary experience.

L-1226 Technical graduate M.E., three years practical experience in design, shop management, purchasing and sales work, also superintendent of company manufacturing high grade gasolene motors, would like similar position.

L-1227 Member, M.I.T. graduate in mechanical engineering with post-graduate course in electrical engineering, twenty years experience in design and construction of machinery and building, manufacturing, systematizing, accounting, refrigeration and as consulting engineer, desires permanent position with headquarters in New York.

L-1228 Member, 17 years experience, familiar with foundry and shop practice, sales engineering including correspondence and testing engineering, desires position in manufacturing concern in executive capacity, either at factory or in charge of branch office. At present employed in responsible position.

L-1229 Junior, graduate in mechanical engineering, age 29, five and one half years experience including machine shop, designing, inspecting, estimating and executive positions, desires to get into efficiency engineering work.

L-1230 Member, publicity manager, fully experienced and capable of taking entire charge of advertising department, manufacturing or selling concern, now employed by well-known corporation, wishes broader field and opportunities. New York interview requested with reliable organization wanting tangible results.

L-1231 Mechanical engineer with shop experience and 11 years thorough experience in constructing, building and maintaining various lines of plants and machinery, desires position along similar lines.

L-1232 Junior, technical graduate, 12 years practical experience in design, construction and maintenance of gas and gasolene engines, and sub-stations and power houses high voltage design and construction. At present employed.

L-1233 Junior member, Associate, A.I.E.E., age 30, technical graduate, experienced in power plant design and construction, operating analyses, public utilities evaluations and reports, desires a position. Salary moderate.

L-1234 Junior, Stevens graduate, age 30, capable executive in new and re-construction and equipment of mills and factories; designer along electrical and steam power lines, structural and reinforced concrete architecture, desires an engagement.

L-1235 Member, mechanical engineer, successful executive, who can organize and supervise an efficient organization, desires position as works manager, superintendent or assistant to chief engineer.

L-1236 Member, graduate M.I.T. in mechanical engineering, age 43, married. Four years instructor mechanical engineering department, M.I.T., eight years experience in design of power plants for public service and industrial uses, including the purchase and installation of equipment; six years general manager steam boiler and plate iron works.

L-1237 Member, graduate M.I.T., hydraulic and electrical engineer, age 44. Manufacturing, consulting and operating experience in this country and Germany; recently connected with some of the largest and typical hydraulic power plant installations.

ACCESSIONS TO THE LIBRARY

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

AIR-TANK REGULATIONS, PRESCRIBED BY THE BOARD OF BOILER RULES, COMMONWEALTH OF MASSACHUSETTS. *Boston, 1914.* Gift of John A. Stevens.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Condensed catalogues of mechanical equipment. vol 4, 1914. *New York, 1914.* Gift.

BESSEMER, GÖRANSSON AND MUSHET, E. F. Lange. A Contribution to technical history. *Manchester, 1913.* Gift of author.

BRAZING AND SOLDERING, H. F. Hobart. ed. 5. *New York, 1912.*

DER BRÜCKENBAU, M. Strukel. II Teil. *Leipzig, 1913.*

COAL GAS RESIDUALS, F. H. Wagner. New York, McGraw-Hill Book Co., 1914. Gift of Publisher.

Just at the present time, the problem of the utilization of coal gas residuals is attracting great attention, and this book is therefore a very timely one. The author, however, confines himself to the manufacture of tar, naphthalene, cyanogen, ammonia and benzol, which may be called the primary derivatives. The work summarizes European practice, some of which is little known in this country. W. P. C.

A CREDIT UNION PRIMER. An elementary treatise on co-operative banking, containing questions and answers concerning methods of organization and operation, necessary books and forms, suggested by-laws and the credit union law of New York, A. H. Ham and L. G. Robinson. *New York, 1914.* Gift of Russell Sage Foundation.

ENTWERFEN VON LEICHTEN BENZINMOTOREN INSBESONDERE VON LUFTFAHRZEUGMOTOREN, O. Winkler. *Berlin, 1914.*

LE GAZ, René Masse. 3 vols. *Paris et Liége, 1914.*

HANDBOOK FOR MACHINE DESIGNERS AND DRAFTSMEN, F. A. Halsey. *New York, 1913.*

HEAT ENGINES, H. R. Allen and J. A. Bursley. ed. 2. *New York, 1914.*

DIE KUPPLUNGEN DER WALZWERKE, F. Peter. *Halle a. S., 1914.*

MANUAL OF MECHANICAL DRAWING, J. H. Dales. Cambridge, University Press, 1914. Gift of G. P. Putnam's Sons.

A very carefully prepared manual for the beginner in mechanical drawing. Beginning with the elements of line, the student is finally led to the making of full detail drawings for an eight-inch lathe. W. P. C.

MASSACHUSETTS PUBLIC SERVICE COMMISSION. First Annual Report. vols. 1-2. *Boston, 1914.* Gift of Commission.

MELLON INSTITUTE OF INDUSTRIAL RESEARCH AND SCHOOL OF SPECIFIC INDUSTRIES. Industrial Fellowships, 1914. *Pittsburgh, 1914.* Gift of University of Pittsburgh.

NAVAL RECIPROCATING ENGINES AND AUXILIARY MACHINERY, J. K. Barton and H. O. Stickney. ed. 3 with plates. 2 vols. *Annapolis, 1914.*

NEW JERSEY PUBLIC UTILITY COMMISSIONERS. Abstracts of Reports made by public utilities to the Board. 1912. *Trrenton, 1914.* Gift of Board of Public Utility Commissioners.

NEW YORK SOCIETY OF ARCHITECTS. Year Book, July 1914. *New York, 1914.* Gift of Society.

NEW YORK (CITY) DEPARTMENT OF BRIDGES. Annual Report, 1913. *New York, 1913.* Gift of F. J. H. Kracke.

NEW YORK (STATE) CONSERVATION COMMISSION. Second Annual Report, 1912. *Albany, 1913.* Gift of Conservation Commission.

NOUVELLES RECHERCHES SUR LA RESISTANCE DE L'AIR ET L'AVIATION WITH ATLAS, G. Eiffel. 2 vols. *Paris, 1914.* Gift of author.

The author, who is an honorary member of the A. S. M. E., describes in this book his new laboratory at Auteuil and the researches made there under conditions which permit him to keep up a work of experimentation which has been universally recognized as classical at the highest level of achievement.

The following are among the subjects treated in the present publication: graphical methods of treating problems connected with the design of planes and aeroplanes, which the author applies to the determination of equilibrium and stability of aeroplanes, moment of stability, volplaning, weight and useful power of an aeroplane, maximum of velocity for a given power, minimum power necessary to fly with a given weight. The author discusses further the problems concerning the center of gravity, vertical rudder, etc.

Chapter 3 presents a very interesting experimental investigation of the behavior of round and curved bodies with respect to air resistance, and with particular regard to shapes applicable to dirigible construction, while the rest of the book covers matters of such primary importance for aeroplane designers as wing resistance, mutual influence of superimposed planes, aeroplane construction, accessories, etc., dirigibles, pressure of air on dirigible hangars, and propellers (in connection with the latter attention is called to Note V, Concerning a Family of Propellers with Several Variable Parameters). The work is mainly of an experimental nature, and as such cannot be abstracted for a review. But it will be no exaggeration to say that its appearance marks an important step in the development of the science of aircraft design. L. G.

OHIO PUBLIC UTILITIES COMMISSION. Report of Joint Committee on Valuation. 1914. Gift of L. B. Webster.

AUS DER PRAXIS DES TAYLOR-SYSTEMS, Rudolf Seubert. *Berlin, 1914.*

SCIENCE OF BURNING LIQUID FUEL, W. N. Best. *New York, 1913.* Gift of author.

SKIZZEN UND TABELLEN ÜBER HEBEZEUGE, Georg Dreyer. *Ilmenau, 1903.* Gift of Hunt Memorial Fund.

STEAM CHARTS, ALSO A TABLE OF THEORETICAL JET VOLOCITIES AND THE CORRECTIONS OF MERCURY COLUMNS WITH FIFTY ILLUSTRATIVE PROBLEMS, F. O. Ellenwood. J. Wiley & Sons, *New York, 1914.* Gift of Publishers.

A useful little book. The introduction gives a review of the fundamental notions of thermodynamics, which is followed by chapters on the preparation and use of the steam charts and tables of velocities, and on atmospheric pressures and barometric corrections; then the charts and tables, followed in their turn by a number of problems with complete solutions serving as an illustration of the instructions as to the use of the tables and charts. The charts have been plotted mainly from the steam tables of Marks and Davis. Attention is called to the way the author handles the region of very low pressures, e. g., in chart 6e. L. G.

A SUGGESTED EXTENSION OF THE DEWEY DECIMAL SYSTEM OF CLASSIFICATION TO GAS ENGINEERING, D. S. Knauss. Written for the accounting section of the 9th annual meeting of the American Gas Institute, Oct. 1914. Gift of C. W. Rice.

TASCHENBUCH FÜR BAUINGENIEURE, Max Foerster. ed. 2. *Berlin, 1914.*

TASCHENBUCH FÜR DEN MASCHINENBAU, H. Dubbel. *Berlin, 1914.*

TECHNISCHE MECHANIK, Ed. Autenrieth, neu bearbeitet von Max Ensslin. ed. 2. *Berlin, 1914.*

THEORIE DES KREISELS. Heft. 1—Die minematischen und kinetischen grundlagen der theorie, F. Klein und A. Sommerfeld. *Leipzig, 1914.*

VORLESUNGEN ÜBER WASSERKRAFTMASCHINEN, E. Camerer. *Leipzig, 1914.*

VORSTUDIEN ZUR EINFÜHRUNG DES SELBSTTÄTIGEN SIGNALSYSTEMS AUF DER BERLINER HOCH-UND UNTERGRUNDBAHN, G. Kemmann. *Berlin, 1914.*

WAHL, PROJEKTIERUNG UND BETRIEB VON KRAFTANLAGEN. Friedrich Barth. *Berlin, 1914.*

WESTERN RESERVE UNIVERSITY. Reports of the President and other officers, 1913-14. *Cleveland, 1914.* Gift of University.

RADIATORS AND HEAT TRANSMISSION, WITH SPECIAL REFERENCE TO PRESSED STEEL RADIATORS

ARGUMENT FOR SHEET METAL RADIATION; EFFICIENCY AND RESISTANCE TO CORROSION, Herbert Orr. *Metal Worker,* vol. 74, pp. 192-193. 1910. From paper read before the National District Heating Association. Pressed steel and cast iron radiators are compared.

THE RELATIVE EFFICIENCY AND DURABILITY OF CAST IRON AND PRESSED STEEL RADIATORS, Ray D. Lillibridge. *Heating and Ventilating Magazine,* September 1908, pp. 33-35.

NEUERE HEIZKÖRPER. *Gesundheits Ingenieur,* February 10, 1912, pp. 97-101. Gives results of tests made by Prof. K. Brabbée at the Königl. Techn. Hochschule, Berlin. Radiators of cast iron, wrought iron, sheet copper, glass and porcelain were tested; in all, about 70 radiators had been tested during the year. The coefficient of heat transmission is given for most of the materials.